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MDXVIII
Ο ΒΙΟϹ
ΤΕΧΝΗ
ΒΡΑΧΥϹ Η
ΔΕ
ΜΑΚΡΗ

Sir Thos. Lawrence pinxt. W. H. Worthington sculpt.

H. Davy

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THE LIFE

OF

SIR HUMPHRY DAVY,

BART. LL.D.

LATE PRESIDENT OF THE ROYAL SOCIETY, FOREIGN ASSOCIATE OF THE ROYAL INSTITUTE OF FRANCE

&c. &c. &c.

BY

JOHN AYRTON PARIS, M.D. CANTAB. F.R.S. &c.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS.

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TO

HIS ROYAL HIGHNESS

PRINCE AUGUSTUS FREDERICK,

DUKE OF SUSSEX, K.G. D.C.L.

&c. &c. &c.

PRESIDENT OF THE ROYAL SOCIETY;

THESE MEMOIRS OF A PHILOSOPHER

WHOSE SPLENDID DISCOVERIES

ILLUMINED THE AGE IN WHICH HE LIVED,

ADORNED THE COUNTRY WHICH GAVE HIM BIRTH,

AND OBTAINED FROM FOREIGN AND HOSTILE NATIONS

THE HOMAGE OF ADMIRATION AND

THE MEED OF GRATITUDE,

ARE, BY THE GRACIOUS PERMISSION OF HIS ROYAL HIGHNESS,

DEDICATED WITH SENTIMENTS OF PROFOUND RESPECT,

BY

THE AUTHOR.

PREFACE.

The reflecting portion of mankind has ever felt desirous of becoming acquainted with the origin, progress, habits, and peculiarities of those whom the powers of genius may have raised above the plane of intellectual equality; but neither the nature of the information, nor the extent of the detail that may be necessary to satisfy so laudable a curiosity, can ever be estimated by any common standard, since it is not in our nature to contemplate an object of admiration, but with reference to our own predilections and sympathies; and hence every reader will form a scale for himself, according to the degree of interest he may feel for the particular character under review. The Poetical enthusiast, who could not sufficiently express his gratitude on being told that Milton wore shoe-buckles, would very probably have not given 'four farthings,' as Gray says, to know that the shoes of Davy were tanned by catechu; and yet if the relative value of this information were fairly estimated, it must be admitted that the former is a matter of barren curiosity, the latter a fact of some practical utility. In a word, we very naturally connect the man with his works, and we care not to extend our acquaintance with the one, but in proportion as we have derived pleasure from the other.

In like manner, very different estimates will be formed of the degree of praise due to a distinguished philosopher, because the few who are deeply imbued with a knowledge of the science he may have adorned and enlightened must not only appreciate the value of his labours, but understand the difficulties which opposed the accomplishment of them, before they can arrive at a sound decision upon the question; and here again the judgment of the most scientific may be unfortunately warped; it may be corrupted by secret passions or sinister influences; be distorted by the prejudices of education and habit, or unduly biassed by invincible prepossessions.

No man ever soared, like an eagle, to the pinnacle of fame, without exciting the envy and perhaps the hatred of those who could only crawl up half way; while, on the other hand, where no rivalry can exist, the splendour of such an ascent will captivate the bystander, and by exciting intemperate triumph and unqualified admiration, change without diminishing the sources of erroneous judgment, and substitute adulation for calumny. Under such circumstances, an allusion even to the common frailties of genius becomes offensive; the biographer is called upon for the delineation of a perfect man; but the world is satisfied with nothing short of 'a faultless monster;' and yet, while they would impose upon him the same restraint as Queen Elizabeth laid upon her artist—to execute a portrait without a single shadow, they little imagine how completely they obscure the features of their idol, by the haze of incense in which they continually envelope it. These are evils against which a future historian will not have to contend; for time tries the characters of men, as the furnace assays the quality of metals, by disengaging the impurities, dissipating the superficial irridescence, and leaving the sterling gold bright and pure.

Nor can the extent of our obligations to a philosopher be appreciated until time shall have shown the various important purposes to which his discoveries may administer. The names of Mayow and Hales might have been lost in the stream of discovery, had not the results of Priestley and Lavoisier shown the value and importance of their statical experiments on the chemical relations of air to other substances. The discoveries of Dr. Black on the subject of *latent* heat could never have obtained that celebrity they now enjoy, had not Mr. Watt availed himself of their application for the improvement of the steam-engine; and the views of Sir H. Davy respecting the true nature of chlorine become daily more important from the discovery of new elements of an analogous nature. In future ages, the metals of the alkalies and earths may admit of applications, and open new avenues of knowledge, of which at present we can form no idea; but it is obvious that, in the page of history, his name will gather fame in proportion as such discoveries unfold themselves.

It must be admitted, that such considerations may furnish an argument against the propriety of writing the life of a contemporaneous philosopher; and yet I will never admit, with Mr. Babbage, that "the volume of his biography should be sealed, until the warm feelings of surviving kindred and admiring friends shall be cold as the grave, from which remembrance vainly recalls his cherished form, invested with all the life and energy of recent existence."

Is it not possible that the errors of partiality, which have so frequently been charged upon the writer on these occasions, may often be ascribed, with greater truth and justice, to the prejudices of the reader—that, after all, the distortion might not have existed in the portrait itself, but in the optics of the observer? Such an opinion, however, even were it true, carries along with it no consolation to the biographer; for I know of no method by which the picture can be adapted to the focus of every eye.

If, however, contemporaneous biography has its difficulties and impediments, so has it also its advantages. Dr. Johnson has remarked, in his Life of Addison, that "History may be formed from permanent monuments and records; but Lives can only be written from personal knowledge, which is growing every day less, and in a short time is lost for ever. The delicate features of the mind, the nice discriminations of character, and the minute peculiarities of conduct, are soon obliterated."

I did not enter upon this arduous and delicate task, without a distinct conception of the various difficulties which would necessarily oppose its accomplishment. I well knew that the biographer of Davy must hold himself prepared for the dissatisfaction of one party at the commendations he might bestow, and for the displeasure of the other, at the penury of his praise, or the asperity of his criticism.

After great labour and much anxiety, I have at length completed the work; and in giving it to the world, I shall apply to myself the words of Swift—"I have the ambition to wish, at least, that both parties may think me in the right; but if that is not to be hoped for, my next wish should be, that both might think me in the wrong, which I would understand as an ample justification of myself, and a sure ground to believe that I have proceeded, at least, with impartiality, and perhaps even with truth."

It is certainly due to myself, and perhaps to the world, to state the circumstances by which I was induced to undertake a work requiring for its completion a freedom from anxiety, and an extent of research, scarcely compatible with the occupations of a laborious profession; and which, I may add, has been wholly composed during night, in hours stolen from sleep. Very shortly after the death of Sir Humphry Davy, an account of his life, written by no friendly hand, nor 'honest chronicler,' was submitted for my judgment by a Journalist who had intended to insert it in his paper. At my request, it was committed to the flames; but not until I had promised to supply the loss by another memoir. The sketches by which I redeemed this pledge were published in a weekly journal—THE SPECTATOR; and they have since been copied into various other works, sometimes with, but frequently without any acknowledgment. They constitute the greater part of the life which was printed in the Annual Obituary for 1829; and they form the introduction to an edition of his "Last Days," lately published in America.

I was soon recognised as the writer of these Sketches; and the leading publishers of the day urged me to undertake a more extended work. To these solicitations I returned a direct refusal: I even declined entering upon any conversation on the occasion; feeling that the wishes of Lady Davy, at that time on the Continent, ought in the very first instance to be consulted on the subject. Had not the common courtesy of society required such a mark of attention, the wish expressed by Sir Humphry in his Will would have rendered it an imperative duty. On her arrival in London, in consequence of a letter she had addressed to Mr. Murray, I requested an interview with her Ladyship, from whom I received not only an unqualified permission to become the biographer of her illustrious husband, but also the several documents which are published with acknowledgement in these memoirs. I still felt that Dr. Davy might desire to accomplish the task of recording the scientific services of his distinguished brother; and, had that been the case, I should most undoubtedly have retired, without the least hesitation or reluctance; but I was assured by those who were best calculated to form an opinion upon this point,—for he was himself absent from England,—that motives of delicacy which it was easy to appreciate, would at once lead him to decline an undertaking embarrassed with so many personal considerations. The task, however, of collating the various works of Sir H. Davy, and of enriching them by notes derived from his own knowledge of the circumstances under which they were written, I do hope will be accomplished by one who is so well calculated to heighten the interest, and to increase the value of labours of such infinite importance to science, and to the best interests of mankind.

The engraving which adorns the volume is from a painting by Sir Thomas Lawrence, presented to the Royal Society by Lady Davy; and I beg the Council of that learned body to accept my thanks for the permission they so readily granted for its being engraved. It is one of the happiest efforts of the distinguished Artist, and is the only portrait I have seen in which his features are happily animated with the expressions of the poet, and whose eye is bent to pursue the flights of his imagination through unexplored regions.

I must also embrace this opportunity of publicly expressing my thanks to the Managers of the Royal Institution, who, in the most handsome manner, immediately complied with my request to inspect their Journals, and to make such extracts from them, as I might consider necessary for the completion of my memoirs.

To Mr. Davies Gilbert, I am under obligations which it is difficult for me to acknowledge in adequate terms, not only for the value of the materials with which he has furnished me, but for the kindness and urbanity with which they were communicated, and for the ready and powerful assistance which I have so constantly received from him during the progress of the work.

To the other enlightened individuals from whom I have received support, I have acknowledged my obligations in the body of the work; and should I have inadvertently passed over any service without a becoming notice, I trust the extent of the labour and the circumstances under which it has been performed, will plead my apology.

Dover Street, January 1, 1831.

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LIFE OF SIR HUMPHRY DAVY,

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CHAPTER I.

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HUMPHRY DAVY was born at Penzance, in Cornwall, on the 17th of December, 1778.* His ancestors had long possessed a small estate at Varfell, in the parish of Ludgvan, in the Mount's Bay, on which they resided: this appears from tablets in the church, one of which bears a date as far back as 1635. We are, however, unable to ascend higher in the pedigree than to his paternal grandfather, who seems to have been a builder of considerable

* I have been favoured by the Rev. C. Val. Le Grice, of Trereiffe, with the following extract from the Parish Register, kept at Madron:—"Humphry Davy, son of Robert Davy, baptized at Penzance, January 22, 1779."

repute in the west of Cornwall, and is said to have planned and erected the mansion of *Trelissick*, near Truro, at present the property and residence of Thomas Daniel, Esq.

His son, the parent of the illustrious subject of our history, was sent to London, and apprenticed to a carver in wood, but, on the death of his father, who, although originally a younger son, had latterly become the representative of the family, he found himself in the possession of a patrimony amply competent for the supply of his limited desires, and therefore pursued his art rather as an object of amusement than one of necessity: in the town and neighbourhood of Penzance, however, there remain many specimens of his skill; and I have myself seen several chimney-pieces curiously embellished by his chisel.*

I am not able to discover that he was remarkable for any peculiarity of intellect; he passed through life without bustle, and quitted it with the usual regrets of friends and relatives. The habits, however, generally imputed to him were certainly not such as would have induced us to anticipate a high degree of steadiness in the son.

His wife, whose maiden name was Grace Millett, was remarkable for the placidity of her temper, and for the amiable and benevolent tendency of her disposition: she had been adopted and brought up, together with her two sisters, under circumstances of affecting interest, by Mr. John Tonkin, an eminent surgeon and apothecary in Penzance; a person of very considerable natural endowments, and whose Socratic sayings are, to this day, proverbial with many of the older inhabitants.

To withhold a narrative of the circumstances that led Mr. Tonkin to the adoption of these orphan children, would be a species of historical fraud and literary injustice, by which the world would not only lose one of those bright examples of pure and disinterested benevolence, which cheer the heart and ornament our nature, but the medical profession would be deprived of an additional claim to that public veneration and regard, to which the kind sympathy of its professors has so universally entitled it.

* Soon after the days of Gibbons, the art of ornamental carving in wood began to decay, and it may now be considered as nearly lost. Its decline may be attributed to two causes. In the first place, to the change of taste in fitting up the interior of our mansions; and in the next, to the introduction of composition for the enrichment of picture-frames and other objects of ornament. "Robert Davy," says a correspondent, "has been considered in this neighbourhood as the Last of the Carvers, and from his small size, was generally called *The little Carver*.

The parents of these children, having been attacked by a fatal fever, expired within a few hours of each other: the dying agonies of the surviving mother were sharpened by her reflecting on the forlorn condition in which her children would be left; for, although the Milletts were originally aristocratic and wealthy, the property had undergone so many subdivisions, as to have left but a very slender provision for the member of the family to whom she had united herself.

The affecting appeal which Mrs. Millett is said to have addressed to her sympathising friend, and medical attendant, was not made in vain: on her decease, Mr. Tonkin immediately removed the three children to his own house, and there they continued with their kind benefactor, until each, in succession, found a home by marriage.

The eldest sister, Jane, was married to Henry Sampson, a respectable watchmaker at Penzance; the youngest, Elizabeth, to her cousin, Leonard Millett of Marazion; neither of whom had any family. The second sister, Grace, was married to Robert Davy, from which union sprang five children, two boys and three girls, the eldest being Humphry, the subject of our memoir, and the second son, John, now Dr. Davy, a Surgeon to the Forces, and a gentleman distinguished by several papers in the Philosophical Transactions.

Humphry Davy was nursed by his mother, and passed his infancy with his parents;* but his childhood, after they had removed from Penzance to reside on their estate at Varfell, was spent partly with them and partly with Mr. John Tonkin, who extended his disinterested kindness from the mother to all her children, but more especially to Humphry, who is said, when a child, to have exhibited powers of mind superior to his years. I have spared no pains in collecting materials for the illustration of the earlier periods of his history; as, to estimate the magnitude of an object, we must measure the base with accuracy, in order to comprehend the elevation of its summit.

He was first placed at a preparatory seminary kept by a Mr. Bushell, who was so struck with the progress he made, that he urged his father to remove him to a superior school.

It is a fact worthy, perhaps, of being recorded, that he would at the age of about five years turn over the pages of a book as rapidly as if he were

* For these materials I acknowledge myself indebted to Dr. Penneck of Penzance, and to Mrs. Millett, Sir H. Davy's sister. The facts were communicated in letters to Lady Davy, by whom they were kindly placed at my disposal.

merely engaged in counting the number of leaves, or in hunting after pictures; and yet, on being questioned, he could generally give a very satisfactory account of the contents. I have been informed by Lady Davy that the same faculty was retained by him through life, and that she has often been astonished, beyond the power of expression, at the rapidity with which he read a work, and the accuracy with which he remembered it. Mr. Children has also communicated to me an anecdote, which may be related in illustration of the same quality. Shortly after Dr. Murray had published his system of chemistry, Davy accompanied Mr. Children in an excursion to Tonbridge, and the new work was placed in the carriage. During the occasional intervals in which their conversation was suspended, Davy was seen turning over the leaves of the book, but his companion did not believe it possible that he could have made himself acquainted with any part of its contents, until at the close of the journey he surprised him with a critical opinion of its merits.

The book that engaged his earliest attention was "The Pilgrim's Progress," a production well calculated, from the exuberance of its invention, and the rich colouring of its fancy, for seizing upon the ardent imagination of youth. This pleasing work, it will be remembered, was the early and especial favourite of Dr. Franklin, who never alluded to it but with feelings of the most lively delight.

Shortly afterwards, he commenced reading history, particularly that of England; and at the age of eight years he would, as if impressed with the powers of oratory, collect together a number of boys in a circle, and mounting a cart or carriage that might be standing before the inn near Mr. Tonkin's house, harangue them on different subjects, and offer such comments as his own ideas might suggest.

He was, moreover, at this age, a great lover of the marvellous, and amused himself and his schoolfellows by composing stories of romance and tales of chivalry, with all the fluency of an Italian improvisatore; and joyfully would he have issued forth, armed *cap-à-pié*, in search of adventures, and to free the world of dragons and giants.

In this early fondness for fiction, and in the habit of exercising his ingenuity in creating imagery for the gratification of his fancy, Davy and Sir Walter Scott greatly resembled each other. The Author of Waverley, in his general preface to the late edition of his novels, has given us the following account of this talent. "I must refer to a very early period of my life, were

I to point out my first achievement as a tale-teller; but I believe most of my old schoolfellows can still bear witness that I had a distinguished character for that talent, at a time when the applause of my companions was my recompense for the disgraces and punishments which the future romance-writer incurred for being idle himself, and keeping others idle, during hours that should have been employed on our tasks." Had not Davy's talents been diverted into other channels, who can say that we might not have received from his inventive pen a series of romantic tales, as beautifully illustrative of the early history of his native county as are the Waverley Novels of that of Scotland? for Cornwall is by no means deficient in elfin sprites and busy "*piskeys;*" the invocation is alone required to summon them from their dark recesses and mystic abodes.

Davy was also in the frequent habit of writing verses and ballads; of making fireworks, and of preparing a particular detonating composition, to which he gave the name of "Thunder-powder," and which he would explode on a stone to the great wonder and delight of his young playfellows.

Another of his favourite amusements may also be recorded in this place; for, however trifling in itself the incident may appear, to the biographer it is full of interest, as tending to show the early existence of that passion for experiment, which afterwards rose so nobly in its aims and objects, as the mind expanded with the advancement of his years. It consisted in scooping out the inside of a turnip, placing a lighted candle in the cavity, and then exhibiting it as a lamp; by the aid of which he would melt fragments of tin, obtained from the metallic blocks which commonly lie about the streets of a coinage town, and demand from his companions a certain number of pins for the privilege of witnessing the operation.

At an early age, but I am unable to ascertain the exact period, he was placed at the Grammar School in Penzance, under the Rev. J. C. Coryton; and whilst his father resided at Varfell, he lived with Mr. Tonkin, except during the holidays, which he always spent with his parents.

He was extremely fond of fishing; and as soon as he became old enough to carry a gun, a portion of his leisure hours was passed in the recreation of shooting; a pursuit which also enabled him to form a collection of the rare birds which occasionally frequented the neighbourhood, and which he is said to have stuffed with more than ordinary skill.

When at home, he frequently amused himself with reading and sketching, and sometimes with caricaturing any thing which struck his fancy; on some occasions he would shut himself up in his room, arrange the chairs, and lecture to them by the hour together.

I have been informed by one of his schoolfellows, a gentleman now highly distinguished for his literary attainments, that, in addition to the amusements already noticed, he was very fond of playing at "Tournament," fabricating shields and visors of pasteboard, and lances of wood, to which he gave the appearance of steel by means of black-lead. Thus equipped, the juvenile combatants, like Ascanius and the Trojan youths of classic recollection, would tilt at each other, and perform a variety of warlike evolutions.

By this anecdote we are forcibly reminded of the early taste of Sir William Jones, who, when a boy at Harrow School, invented a political play, in which William Bennet, Bishop of Cloyne, and the celebrated Dr. Parr, were his principal associates. They divided the fields in the neighbourhood of Harrow, according to a map of Greece, into states and kingdoms; each fixed upon one as his dominion, and assumed an ancient name. Some of their schoolfellows consented to be styled Barbarians, who were to invade their territories and attack their hillocks, which they denominated fortresses.*

On one occasion, Davy got up a Pantomime; and I have very unexpectedly obtained a fly-leaf, torn out of a Schrevelius' Lexicon, on which the *Dramatis Personæ*, as well as the names of the young actors, were registered, as originally cast. This document appears so interesting, that I have thought it right to preserve it on record.

Father	Cunnack.
Harlequin	Davy.
Clown	* * * * * *†
Columbine	Hichens.
Cupid	Veale.
Fortuna	Scobell.
Ben	Billy Giddy.
Nurse	Robyns.
Maccaroni	Dennis.

The performers, who, I believe, with one exception, are all living, will perhaps find some amusement in examining how far their future characters were

* Life of Sir William Jones, by Lord Teignmouth.

† Here, as Mrs. Ratcliffe would say, the Legend isso effaced by damp and time, as to be wholly illegible.

shadowed forth on this occasion. At all events, I feel confident that they will receive no small gratification at having their recollections thus carried back to the joyous scenes of boyhood, connected as they always are, and must ever be, with the most delightful associations of our lives.

From Penzance school he went to Truro, in the year 1793, and finished his education under the Rev. Dr. Cardew, a gentleman who is distinguished by the number of eminent scholars with which he has graced his country.

That Davy was quick and industrious in his school exercises, may be inferred from an anecdote related by his sister, that "on being removed to Truro, Dr. Cardew found him very deficient in the qualifications for the Class of his age, but on observing the quickness of his talents, and his aptitude for learning, he did not place him in a lower form, telling him that by industry and attention he trusted he might be entitled to keep the place assigned to him; which," his sister says, "he did, to the entire satisfaction of his master."

It is very natural that an anecdote so gratifying to the family should have been deeply imprinted on their memory; but we must not be surprised on finding that it did not make a similar impression upon Dr. Cardew. From a letter lately addressed by that gentleman to Mr. Davies Gilbert, the following is an extract:—"With respect to our illustrious countryman, Sir H. Davy, I fear I can claim but little merit from the share I had in his education. He was not long with me; and while he remained I could not discern the faculties by which he was afterwards so much distinguished; I discovered, indeed, his taste for poetry, which I did not omit to encourage." Dr. Cardew adds, "While engaged in teaching the classics, I was anxious to discharge faithfully the duties of my profession to the best of my ability; but I was certainly fortunate in having so many good materials to work upon, and thus having only '*fungi vice cotis*,' though '*exsors ipse secandi*.'" To the truth of this latter part of the Doctor's quotation, will his scholars willingly subscribe? I doubt how far Dr. Cardew was able to descend into the shadowy regions of Maro, without the "*donum fatalis virgæ*."

Mrs. Millett thinks that the deficiency just alluded to may be attributed to Mr. Coryton, rather than to the inattention of her brother; the former having, from his neglect as a master, given very general dissatisfaction. From what I can learn, at this distant period, of the character of Mr. Coryton, it appears at all events, that the "*exsors ipse secandi*" could not have been justly applied to him ; and that, owing to an unfortunate aptness in the name to a doggrel verse, poor Davy had frequently to smart under his tyranny.

" Now, Master Dàvy,
Now, Sir, I hàve 'e,
No one shall sàve 'e,
Good Master Dàvy ;"

when the master, suiting the action to the rythm, inflicted upon the hand of the unlucky scholar the verberations of that type and instrument of pedagoguish authority — the flat ruler. Here we have another example of the seduction of sound, argued by our great jurist Mr. Bentham,* to have determined the maxims of that law, which has been pronounced by its sages the perfection of reason.

From a letter however, written by Davy a few years afterwards, respecting the education of a member of his family, he would appear to have entertained an opinion not very unlike that of John Locke ; for, although he testifies the highest respect for Dr. Cardew, he seems to consider the comparative idleness of his earlier school career, by allowing him to follow the bent of his own mind, to have favoured the developement of his peculiar genius. " After all," he says, " the way in which we are taught Latin and Greek, does not much influence the important structure of our minds. I consider it fortunate that I was left much to myself as a child, and put upon no particular plan of study, and that I enjoyed much idleness at Mr. Coryton's school. I perhaps owe to these circumstances the little talents I have, and their peculiar application ; — what I am I have made myself — I say this without vanity, and in pure simplicity of heart."

His temper during youth is represented as mild and amiable. He never suppressed his feelings, but every action was marked by ingenuousness and candour, qualities which endeared him to his youthful associates, and gained him the love of all who knew him. " Nor can I find," says his sister, " beloved as he must have been by my mother, that she showed him

* " Were the enquiry diligently made," he says, " it would be found that the Goddess of Harmony has exercised more influence, however latent, over the dispensations of Themis, than her most diligent historiographers, or even her most passionate panegyrists, seem to be aware of. Every one knows how, by the ministry of Orpheus, it was she who first collected the sons of men beneath the shadow of the sceptre: yet in the midst of continual experience, men seem yet to learn with what successful diligence she laboured to guide it in its course."

any particular preference; — all her children appeared to be alike her care, and all alike shared her affection."

In 1794, Mr. Davy died. We cannot but regret that he did not live long enough to witness his son's eminence; for life, as Johnson says, has few better things to give than a talented son; but from his widow, who has but lately descended to the tomb, full of years and respectability, this boon was not withheld, she witnessed his whole career of usefulness and honour, and happily closed her eyes before her maternal fears could have been awakened by those signs of premature decay, which for some time had excited in his friends, and in the friends of science, an alarm which the recent deplorable event has too fatally justified.

In the year following the decease of her husband, Mrs. Davy, who had again taken up her residence in Penzance, and entered upon the occupation of a milliner, apprenticed her son,* by the advice of her long-valued friend, Mr. Tonkin, to Mr. John Bingham Borlase, at that time a surgeon and apothecary, but who afterwards obtained a diploma, and became an eminent physician at Penzance. Davy however, for the most part, continued to pursue his own plans of study; for although his friend Mr. Tonkin, without doubt, intended him for a general practitioner in his native town, yet he himself always looked forward to graduation at Edinburgh, as a preliminary measure to his practising in the higher walk of his profession.

His mind had, for some time, been engrossed with philosophical pursuits; but until after he had been placed with Mr. Borlase, it does not appear that he indicated any decided turn for chemistry, the study of which he then commenced with all the ardour of his temperament; and his eldest sister, who acted as his assistant, well remembers the ravages committed on her dress by corrosive substances.

It has been said that his mind was first directed to chemistry, by a desire to discover various mixtures as pigments; a suggestion to which, I confess, I am not disposed to pay much attention; for although he might have sought by new combinations to impart a novel and vivid richness of colouring to his drawings, it was the character of his mind to pursue with ardour every subject of novelty, and to get at results by his own native powers, rather than by the recorded experience of others.

* The original indenture, now in the possession of Mr. R. Edwards, solicitor, of Penzance, is dated February 10th, 1795.

I must here relate an anecdote, in illustration of this statement, which has been lately communicated to me by the Reverend Dr. Batten, the principal of the East India College at Hayleybury. This gentleman was one of the earliest of Davy's schoolfellows, but as he advanced in age, different views, and a different plan of education, carried him to a distant part of the kingdom; the discipline and duties of a cloistered school necessarily estranged him from his native town; and it was not until after his admission at Cambridge, and the arrival of the long vacation, which afforded a temporary oblivion of academic cares, that Mr. Batten returned to Cornwall, to revisit the scenes, and to renew the friendships of his boyish days. Davy, who was at that period an apprentice to Mr. Borlase, received him with transport and affection; but he was no longer the boy that his friend had left him; he had become more serious and contemplative, fond of solitary rambles, and averse to enter into society, or to join the festive parties of the inhabitants. In fact, his mind was now in the act of being moulded by the spirit of Nature; and, without the constraint of study, he was insensibly inhaling knowledge with the wild breezes of his native hills.

In the course of conversation, Mr. Batten spoke of his academic studies; and in alluding to the principles of Mechanics, to which he had lately paid much attention, he expressed himself more particularly pleased with that part which treats of "the Collision of Bodies." What was his surprise, on finding Davy as well, if not better acquainted with its several propositions! It was true that he had never systematically studied the subject—had never perhaps seen any standard work upon it, but he had instituted experiments with elastic and inelastic balls, and had worked out the results by the unassisted energies of his own mind. It is clear that, had this branch of science not existed, Davy would have created it.

During this period of his apprenticeship, he twice a week attended a French school in Penzance, kept by a M. Dugast, a priest from La Vendée; and it was remarked that, although he acquired a knowledge of the grammatical construction of the language with greater facility than any of the other scholars, he could not succeed in obtaining the correct pronunciation; and, in fact, notwithstanding his extensive intercourse with foreigners, and his residence in France, he never, in after life, could speak French either with correctness or fluency.

While with Mr. Borlase, it was his constant custom to walk in the evening to Marazion, to drink tea with an aunt to whom he was greatly attached.

Upon such occasions, his usual companion was a hammer, with which he procured specimens from the rocks on the beach. In short, it would appear that, at this period, he paid much more attention to Philosophy than to Physic; that he thought more of the bowels of the earth, than of the stomachs of his patients; and that, when he should have been bleeding the sick, he was opening veins in the granite. Instead of preparing medicines in the surgery, he was experimenting in Mr. Tonkin's garret, which had now become the scene of his chemical operations; and, upon more than one occasion, it is said that he produced an explosion which put the Doctor, and all his glass bottles, in jeopardy. "This boy Humphry is incorrigible!"—"Was there ever so idle a dog!"—"He will blow us all into the air!" Such were the constant exclamations of Mr. Tonkin; and then, in a jocose strain, he would speak of him as the "Philosopher," and sometimes call him "Sir Humphry," as if prophetic of his future renown.*

For the surgical department of the profession, he always entertained a decided distaste, although the following extract from a letter of my correspondent, Mr. Le Grice, will show that, for once at least, he had the merit of mending a broken head. "The first time I ever saw Davy was on the Battery rocks; we were alone bathing, and he pointed out to me a good place for diving; at the same time he talked about the tides, and Sir Isaac Newton, in a manner that greatly amazed me. I perhaps should not have so distinctly remembered him, but on the following day, by not exactly marking the spot he had pointed out, I was nearly killed by diving on a rock, and he came as Mr. Borlase's assistant to dress the wound."

It was Davy's great delight to ramble along the sea-shore, and often, like the orator of Athens, would he on such occasions declaim against the howling of the wind and waves, with a view to overcome a defect in his voice, which, although only slightly perceptible in his maturer age, was in the days of his boyhood exceedingly discordant. I may perhaps be allowed to observe, that the peculiar intonation he employed in his public addresses, and which rendered him obnoxious to the charge of affectation, was to be referred to a laborious effort to conceal this natural infirmity. It was also clear that he was deficient in that quality which is commonly called "a good ear," and with

* Davy appears to have been more fortunate than his prototype Scheele; for on one occasion, as the latter was employed in making pyrophorus, a fellow apprentice, without his knowledge, put some fulminating powder into the mixture; the consequence was a violent explosion; the whole family was thrown into confusion, and the young chemist was severely chastised.

which the modulation of the voice is generally acknowledged to have an obvious connexion. Those who knew him intimately will readily bear testimony to this fact. Whenever he was deeply absorbed in a chemical research, it was his habit to hum some tune, if such it could be called, for it was impossible for any one to discover the air he intended to sing: indeed, Davy's music became a subject of raillery amongst his friends; and Mr. Children informs me, that, during an excursion, they attempted to teach him the air of God save the King, but their efforts were unavailing.

It may be a question how far the following fact, with which I have just been made acquainted, admits of explanation upon this principle. On entering a volunteer infantry corps, commanded by a Captain Oxnam, Davy could never emerge from the awkward squad; no pains could make him keep the step; and those who were so unfortunate as to stand before him in the ranks, ought to have been heroes invulnerable in the heel. This incapacity, as may be readily supposed, occasioned him considerable annoyance, and he engaged a serjeant to give him private lessons, but it was all to no purpose. In the platoon exercise he was not more expert; and he whose electric battery was destined to triumph over the animosity of nations, could never be taught to shoulder a musket in his native town.

That Davy, in his youth, possessed courage and decision, may be inferred from the circumstance of his having, upon receiving a bite from a dog supposed to be rabid, taken his pocket-knife, and without the least hesitation cut out the part on the spot, and then retired into the surgery and cauterized the wound; an operation which confined him to Mr. Tonkin's house for three weeks. The gentleman from whom I received an account of this adventure, the accuracy of which has been since confirmed by Davy's sister, also told me, that he had frequently heard him declare his disbelief in the existence of pain whenever the energies of the mind were directed to counteract it; but he added, "I very shortly afterwards had an opportunity of witnessing a practical refutation of this doctrine in his own person; for upon being bitten by a congor eel, my young friend Humphry roared out most lustily."

The anecdote of Davy's excising the bitten part with so much promptitude and coolness, derives its interest from the age and inexperience of the operator. In the course of his practice, every physician must have met with similar cases of stern decision; but I will venture to say that they have never occurred except in instances of persons of acknowledged courage. Not many days since, a veteran officer, distinguished for the intrepidity with which he rescued the person of George the Third from the fury of a desperate mob, in St. James's Park, informed me that he had formerly been bitten at Vienna by a dog afterwards ascertained to have been rabid; he immediately entered a blacksmith's shop, and by threats compelled the person at the forge to heat an iron red-hot, and burn his leg to the bone. The blacksmith, after first stipulating that he should strap his eccentric customer to the anvil, reluctantly complied; and my friend showed me a scar which sufficiently testified the complete manner in which the son of Vulcan had performed his engagement:—But to return from this digression.

At this time of day, no one can surely believe with Pope, that a "Ruling Passion" is an innate and irresistible affection antecedent to reason and observation: on the contrary, ample experience has led us to the conclusion, that

————" men's judgments are
A parcel of their fortunes, and things outward
Do draw the inward quality after them."

The prevailing bias of great minds may thus be often traced to some accidental, and apparently trivial, impression in early life; and the acute biographer will, in the course of his observations, continually discover traits of character that are readily referable to such a source, even as in the magical colouring of Rembrandt's works, the practised eye will recognise the *chiaro-oscuro* of his father's mill, in which the artist passed his hours of childhood.

In like manner, that marked aversion to arbitrary power, which ever distinguished the actions and writings of Dr. Franklin, has by himself been referred to the sense of injustice early imprinted upon his mind by the severe and tyrannical conduct of his elder brother; while, at the same time, he tells us that he was indebted for his habit through life, of forming just estimates of the value of things, to his having, at the age of seven years, "paid too much for his whistle."

But circumstances, however disposed and happily combined, although they may direct, can never create genius; it is possible that Cowley might never have been enamoured of the Muses, nor Sir Joshua Reynolds have courted the Graces, but for the casual circumstances recorded by the biographer; and Ferguson might not have turned his attention to mechanical inventions, had not an accident befallen the roof of his father's cottage; and even Priestley, the founder of a new and beautiful department in science, might very probably never have been led to think of pneumatic chemistry, had he not lived in the vicinity of a great brewery; still, however, such men could not have shone dimly, if true genius be correctly defined by Dr. Johnson as "a mind of large general powers accidentally determined to some particular direction."*—So with Davy; his mind was as vigorous as it was original, and no less logical and precise than it was daring and comprehensive; nothing was too mighty for its grasp, nothing too minute for its observation; like the trunk of the elephant, it could tear up the oak of the forest, or gently pluck the acorn from its branch.

That circumstances in early life should have directed such energies to a science, which requires for its advancement all the aids of novel and bold, and yet patient and accurate research, is one of those fortunate events which every unprejudiced mind will view with triumph.

It is surely not difficult to understand how it happened that a mind endowed with the genius and sensibilities of Davy, should have been directed to the study of Chemistry and Mineralogy, when we consider the nature and scenery of the country in which accident had placed him. Many of his friends and associates must have been connected with mining speculations: "Shafts," "Cross Courses," and "Lodes," were words familiarised to his ears; and his native love of enquiry could not have long suffered them to remain strangers to his understanding. Nor could he have wandered along the rocky coast, nor have reposed for a moment to contemplate its wild scenery, without being invited to geological enquiry by the genius of the place; for were we to personify the science, where could we find a more appropriate spot for her "local habitation?" "How often when a boy," said Davy to me, on my showing him a drawing of the wild rock scenery of Botallack Mine, "have I wandered about those rocks in search of new minerals, and, when fatigued, sat down upon the turf, and exercised my fancy in anticipations of scientific renown!"

* M. de Bourrienne, in his "Private Memoirs of Napoleon Bonaparte," appears to have justly appreciated the influence of circumstances upon the destinies of great men. In speaking of Buonaparte at the Military College of Brienne, he says, "If the monks, to whom the superintendence of the establishment was confided, had engaged more able mathematical professors, or if we had had any excitement to the study of Chemistry, or Natural Philosophy, I am convinced that Buonaparte would have pursued those sciences with all the genius and spirit of investigation, which he displayed in a career more brilliant, it is true, but far less useful to mankind."

Such scenery, also, in one who possessed a quick sensibility to the sublime forms of Nature, was well calculated to kindle that enthusiasm which is so essential to poetical genius; and we accordingly learn, that he became enamoured of the Muses at a very early age, and evinced his passion by several poetical productions. I am assured by Dr. Batten that, at the age of twelve years, he had finished an epic poem, which he entitled the "Tydidiad," from its celebrating the adventures of Diomede on his return from the Trojan war. It is much to be regretted that not even a fragment of this poem should have been preserved; but Dr. Batten well remembers that it was characterised by great freedom of invention, vigour of description, and wildness of execution.

At the age of seventeen he became desperately enamoured of a young French lady, at that time resident at Penzance, to whom he addressed numerous sonnets, but these, like the passion that produced them, have long since been extinct.

Several of his minor productions were printed in a work entitled the "Annual Anthology," published in three volumes at Bristol, in 1799; two of which were edited by Southey, and one by James Tobin;—a work of some curiosity, independent of its merits, as the first attempt in this country to establish an "Annual," a species of literary composition which has lately been made very popular and amusing.

These volumes have now become extremely scarce, for which, and other reasons, I have thought it right to place Davy's productions on record in these memoirs; for although they are marked by the common faults of youthful poets, they still bear the stamp of lofty genius. There is, besides, a vein of philosophical contemplation running through their composition, which may be considered as indicating the future character and pursuit of their author; an ardent aspiration after fame seems, even at this early period, to have been felt in all its force, and is expressed in many striking and beautiful passages.

There is still a higher motive by which I am induced to introduce these specimens into my memoir, that of showing the bias of his genius at this early period, with a view to compare it with that which displayed itself in the "last days of the philosopher." We shall find that the bright and rosy hues of fancy which gilded the morning of his life, and were subdued or chased away by the more resplendent light of maturer age, again glowed forth in the evening of his days, and illumined the setting, as it had the dawning of his genius.

His first production bears the date of 1795, and is entitled

THE SONS OF GENIUS.

Bright bursting through the awful veil of night
  The lunar beams upon the Ocean play,
The watery billows shine with trembling light,
  Where the swift breezes skim along the sea.

The glimmering stars in yon ethereal plain
  Grow pale, and fade before the lucid beams,
Save where fair Venus, shining o'er the main
  Conspicuous, still with fainter radiance gleams.

Clear is the azure firmament above,
  Save where the white cloud floats upon the breeze,—
All tranquil is the bosom of the grove,
  Save where the Zephyr warbles through the trees.

Now the poor shepherd wandering to his home
  Surveys the darkening scene with fearful eye,
On every green sees little elfins roam,
  And haggard sprites along the moonbeams fly.

While Superstition rules the vulgar soul,
  Forbids the energies of man to rise,
Rais'd far above her low, her mean controul,
  Aspiring Genius seeks her native skies.

She loves the silent solitary hours,
  She loves the stillness of the starry night,
When o'er the brightening view Selene pours
  The soft effulgence of her pensive light.

'Tis then disturb'd not by the glare of day;
  To mild tranquillity alone resign'd,
Reason extends her animating sway
  O'er the calm empire of the peaceful mind.

Before her lucid, all-enlightening ray,
  The pallid spectres of the Night retire,
She drives the gloomy terrors far away,
  And fills the bosom with celestial fire.

Inspired by her, the Sons of Genius rise
  Above all earthly thoughts, all vulgar care;
Wealth, power, and grandeur they alike despise,
  Enraptured by the good, the great, the fair.

A thousand varying joys to them belong—
  The charms of nature and her changeful scenes;
Their's is the music of the vernal song,
  And their's the colours of the vernal plains.

Their's is the purple-tinged evening ray,
  With all the radiance of the morning sky;
Their's is the splendour of the risen day,
  Enshrined in glory by the sun's bright eye.

For them the Zephyr fans the odorous dale,
  For them the warbling streamlet softly flows,
For them the Dryads shade the verdant vale,
  To them sweet Philomel attunes her woes.

To them no wakeful moonbeam shines in vain
  On the dark bosom of the trackless wood,
Sheds its mild radiance o'er the desert plain,
  Or softly glides along the chrystal flood.

Yet not alone delight the soft and fair,
  Alike the grander scenes of Nature move;
Yet not alone her beauties claim their care,
  The great, sublime, and terrible, they love.

The Sons of Nature, they alike delight
  In the rough precipice's broken steep,
In the black terrors of the stormy night,
  And in the thunders of the threatening deep.

When the red lightnings through the ether fly,
And the white foaming billows lash the shores;
When to the rattling thunders of the sky
The angry Demon of the waters roars;

And when, untouch'd by Nature's living fires,
No native rapture fills the drowsy soul;
Then former ages, with their tuneful lyres,
Can bid the fury of the passions fall.

By the blue taper's melancholy light,
Whilst all around the midnight torrents pour,
And awful glooms beset the face of Night,
They wear the silent solitary hour.

Ah, then, how sweet to pass the night away
In silent converse with the Grecian page!
Whilst Homer tunes his ever-living lay,
Or reason listens to th' Athenian sage;

To scan the laws of Nature, to explore
The tranquil reign of mild philosophy;
Or on Newtonian wings sublime to soar
Through the bright regions of the starry sky.

Ah! who can paint what raptures fill the soul
When Attic Freedom rises to the war,
Bids the loud thunders of the battle roll,
And drives the tyrant trembling from her shore!

From these pursuits the Sons of Genius scan
The end of their creation; hence they know
The fair, sublime, immortal hopes of man,
From whence alone undying pleasures glow.

By Science calm'd, over the peaceful soul,
Bright with eternal Wisdom's lucid ray,
Peace, meek of eye, extends her soft control,
And drives the fury Passions far away.

Virtue, the daughter of the skies supreme,
  Directs their life, informs their glowing lays—
A steady friend ; her animating beam
  Sheds its soft lustre o'er their latter days.

When life's warm fountains feel the frost of time;
  When the cold dews of darkness close their eyes,
She shows the parting soul, upraised sublime,
  The brighter glories of her kindred skies.

Thus the pale Moon, whose pure celestial light
  Has chased the gloomy clouds of Heaven away,
Rests her white cheek, with silver radiance bright,
  On the soft bosom of the Western sea.

Lost in the glowing wave, her radiance dies;
  Yet, while she sinks, she points her ling'ring ray
To the bright azure of the orient skies—
  To the fair dawning of the glorious day.

Like the tumultuous billows of the sea
  Succeed the generations of mankind;
Some in oblivious silence pass away,
  And leave no vestige of their lives behind.

Others, like those proud waves which beat the shore,
  A loud and momentary murmur raise;
But soon their transient glories are no more,—
  No future ages echo with their praise.

Like yon proud rocks amidst the sea of time,
  Superior, scorning all the billow's rage,
The living Sons of Genius stand sublime,
  Th' immortal children of another age.

For those exist whose pure ethereal minds,
  Imbibing portions of celestial day,
Scorn all terrestrial cares, all mean designs,
  As bright-eyed eagles scorn the lunar ray.

Their's is the glory of a lasting name,
  The meed of Genius and her living fires,
Their's is the laurel of eternal fame,
  And their's the sweetness of the Muse's lyres

D.—1795.

THE SONG OF PLEASURE.

The genial influence of the day
Had chased the lingering cold away;
Borne upon the Zephyr's wing,
Sweetly smiled the radiant Spring:
Her mild re-animating breath
Wakes Nature from her wintry death;
Attended by the laughing Hours,
She rises clad in flowers,
And lightly as she trips along,
The vernal warblers raise the song.

Rich in a thousand radiant dyes,
Around her steps the flow'rets rise,
The Zephyr sports, the sunbeams sleep
On the blue bosom of the deep.
And now, within my throbbing breast
I feel the influence of the Spring,
To ecstacy I tune my string,
And garlanded with odorous flowers,
I hasted to the shady grove,
I hasted to the roseate bowers
Where Pleasure dwells with Love.

There Youth, and Love, and Beauty, bound
The glowing rose my harp around;
Then to the Daughter of desire,
To bright-eyed Pleasure gave the lyre,

She tuned the string,
And smiling softer than the rosy sea,
When the young Morning blushes on her breast,
She raised the raptured lay,
I heard her sing,
The song lull'd every care and every thought to rest.

Sons of Nature, hither haste,
The blessings of existence taste;
Listen to my friendly lay,
And your cares shall fly away,
Quick as fly the wintry snows
When the vernal Zephyr blows.
Let others, courting wars alarms,
Seek the bloody field of arms;
Let others, with undaunted soul,
Bid Bellona's thunders roll;
From the lightnings of their eye
Let the trembling squadrons fly;
Sons of Nature, you shall prove
A softer fight, the fight of love.
While you in soft repose are laid
Underneath the myrtle shade,
Amid the murky glooms of Death,
The sons of battle pant for breath.

Let the philosophic sage,
His silver tresses white with age,
Amid the chilling midnight damp,
Waste the solitary lamp,
To scan the laws of Nature o'er,
The paths of Science to explore;
Curb'd beneath his harsh control
The blissful Passions fly the soul.
You, the gentler sons of joy,
Softer studies shall employ!
He to curb the Passions tries,
You shall bid them all arise;

His wants he wishes to destroy,
You shall all your wants enjoy.
Let the laurel, Virtue's meed,
Crown his age-besilver'd head,
The verdant laurel ever grows
Amid the sullen Winter's snows:
Let the rose, the flower of bliss,
The soft unwrinkled temples kiss;
Fann'd by the Zephyr's balmy wing,
The odorous rose adorns the Spring.

Let the Patriot die, to raise
A lasting monument of praise.
Ah, fool, to tear the glowing rose
From the mirth-encircled brows,
That around his dusky tomb
The ever-verdant bay may bloom!
Let Ambition's sons alone
Bow around the tottering throne,
Fly at Glory's splendid rays,
And, moth-like, die amidst a blaze;
You shall bow, and bow alone,
Before delicious Beauty's throne.
Lo! Theora treads the green,
All breathing grace and harmony she moves,
Fair as the mother of the Loves.
In graceful ringlets floats her golden hair;
From the bright azure of her eye
Expression's liquid lightnings fly.
Her cheek is fair,
Fair as the lily, when at dawning day,
Tinged with the morning's bright and purple ray,
Yonder scented groves among
She will listen to your song.

In yonder bower where roses bloom,
Where the myrtle breathes perfume,
You shall at your ease recline,
And sip the soul-enlivening wine;

There the lyre, with melting lay,
Shall bid the soul dissolve away.
Soft as the Morning sheds her purple light
Through the dark azure of the Night,
So soft the God of slumber sheds
His roseate dews around your heads.

Such the blessings I bestow!
Haste, my sons, these blessings know!
Behold the flow'rets of the spring,
They wanton in the Zephyr's wing,
They drink the matin ether blue,
They sip the fragrant evening dew.
Man is but a short-lived flower,
His bloom but for a changeful hour!
Pass a little time away,
The rosy cheek is turn'd to clay,
No living joys, no transports burn
In the dark sepulchral urn,
No *Laurels* crown the fleshless brows,
They fade together with the *Rose.*

D.—1796.

ODE TO SAINT MICHAEL'S MOUNT, IN CORNWALL.

The sober eve with purple bright
Sheds o'er the hills her tranquil light
  In many a lingering ray;
The radiance trembles on the deep,
Where rises rough thy rugged steep,
  Old Michael, from the sea.

Around thy base, in azure pride,
Flows the silver-crested tide,
  In gently-winding waves;
The Zephyr creeps thy cliffs around,—
Thy cliffs, with whispering ivy crown'd,
  And murmurs in thy caves.

Majestic steep! Ah, yet I love,
With many a lingering step, to rove
Thy ivied rocks among;
Thy ivied, wave-beat rocks recall
The former pleasures of my soul,
When life was gay and young.

Enthusiasm, Nature's child,
Here sung to me her wood-songs wild,
All warm with native fire;
I felt her soul-awakening flame,
It bade my bosom burn for fame,—
It bade me strike the lyre.

Soft as the Morning sheds her light
Through the dark azure of the Night
Along the tranquil sea;
So soft the bright-eyed Fancy shed
Her rapturing dreams around my head,
And drove my cares away.

When the white Moon with glory crown'd,
The azure of the sky around,
Her silver radiance shed;
When shone the waves with trembling light,
And slept the lustre palely bright
Upon thy tower-clad head;

Then Beauty bade my pleasure flow,—
Then Beauty bade my bosom glow
With mild and gentle fire!
Then Mirth, and Cheerfulness, and Love,
Around my soul were wont to move,
And thrill'd upon my lyre.

But when the Demon of the deep
Howl'd around thy rocky steep,
And bade the tempests rise,—
Bade the white foaming billows roar,
And murmuring dash the rocky shore,
And mingle with the skies;

Ah, then my soul was raised on high,
And felt the glow of ecstasy,
With *great* emotions fill'd;
Thus joy and Terror reign'd by turns,
And now with LOVE the bosom burns,
And now by FEAR is chill'd.

Thus to the sweetest dreams resign'd,
The fairy FANCY ruled my mind,
And shone upon my youth;
But now, to awful Reason given,
I leave her dear ideal heaven
To hear the voice of TRUTH.

She claims my best, my loftiest song,
She leads a brighter maid along—
DIVINE PHILOSOPHY,
Who bids the mounting soul assume
Immortal Wisdom's eagle plume,
And penetrating eye,

Above Delusion's dusky maze,
Above deceitful Fancy's ways,
With roses clad to rise;
To view a gleam of purest light
Bursting through Nature's misty night,—
The radiance of the skies.

D.—1796.

THE TEMPEST.

THE Tempest has darken'd the face of the skies,
The winds whistle wildly across the waste plain,
The Fiends of the whirlwind terrific arise,
And mingle the clouds with the white-foaming main.

All dark is the night, and all gloomy the shore,
Save when the red lightnings the ether divide,
Then follows the thunder with loud-sounding roar,
And echoes in concert the billowy tide.

But though now all is murky and shaded with gloom,
Hope, the soother, soft whispers the tempests shall cease;
Then Nature again in her beauty shall bloom,
And enamour'd embrace the fair sweet-smiling Peace;

For the bright-blushing morning, all rosy with light,
Shall convey on her wings the Creator of day;
He shall drive all the tempests and terrors of night,
And Nature enliven'd, again shall be gay.

Then the warblers of Spring shall attune the soft lay,
And again the bright flow'ret shall blush in the dale;
On the breast of the Ocean the Zephyr shall play,
And the sunbeam shall sleep on the hill and the dale.

If the tempests of Nature so soon sink to rest—
If her once-faded beauties so soon glow again,
Shall Man be for ever by tempests oppress'd,
By the tempests of passion, of sorrow, and pain?

Ah, no! for his passions and sorrow shall cease
When the troublesome fever of life shall be o'er;
In the night of the grave he shall slumber in peace,
And passion and sorrow shall vex him no more.

And shall not this night and its long dismal gloom,
Like the night of the tempest, again pass away?
Yes! the dust of the earth in bright beauty shall bloom,
And rise to the morning of heavenly day!

D.—1796.

EXTRACT FROM AN UNFINISHED POEM ON MOUNT'S BAY.

Mild blows the Zephyr o'er the Ocean dark,
The Zephyr wafting the grey twilight clouds
Across the waves, to drink the solar rays
And blush with purple.
By the orient gleam
Whitening the foam of the blue wave that breaks

Around his granite feet, but dimly seen,
Majestic Michael rises. He whose brow
Is crown'd with castles, and whose rocky sides
Are clad with dusky ivy: he whose base,
Beat by the storm of ages, stands unmoved
Amidst the wreck of things, the change of time.
That base encircled by the azure waves,
Was once with verdure clad: the tow'ring oaks
There waved their branches green,—the sacred oaks
Whose awful shades among, the Druids stray'd
To cut the hallow'd miseltoe, and hold
High converse with their Gods.

On yon rough crag,
Where the wild Tamarisk whistles to the sea blast,
The Druid's harp was heard, swept by the breeze
To softest music, or to grander tones
Awaken'd by the awful master's hand.
Those tones shall sound no more! the rushing waves,
Raised from the vast Atlantic, have o'erwhelm'd
The sacred groves. And deep the Druids lie
In the dark mist-clad sea of former time.
Ages had pass'd away, the stony altar
Was white with moss, when on its rugged base
Dire Superstition raised the gothic fane,
And monks and priests existed.

On the sea
The sunbeams tremble; and the purple light
Illumes the dark Bolerium,* seat of storms.
High are his granite rocks. His frowning brow
Hangs o'er the smiling Ocean. In his caves
Th' Atlantic breezes murmur. In his caves,
Where sleep the haggard Spirits of the storm,
Wild dreary are the *schistine* † rocks around
Encircled by the wave, where to the breeze

* The Land's End in Cornwall.

† The granite of Cornwall is generally found incumbent on primitive *schistus*. This is the case in many of the cliffs at the Land's End. The upper stratum is composed of granite, the lower with the surrounding rocks of *schistus*. D.

The haggard Cormorant shrieks. And far beyond
Are seen the cloud-like Islands, grey in mists.*

Thy awful height, Bolerium, is not loved
By busy Man, and no one wanders there
Save he who follows Nature,—he who seeks
Amidst thy crags and storm-beat rocks to find
The marks of changes teaching the great laws
That raised the globe from chaos; or he whose soul
Is warm with fire poetic,—he who feels
When Nature smiles in beauty, or sublime
Rises in majesty,—he who can stand
Unawed upon thy summit, clad in tempests,
And view with raptured mind the roaring deep
Rise o'er thy foam-clad base, while the black cloud
Bursts with the fire of Heaven—
He whose heart
Is warm with love and mercy,—he whose eye
Drops the bright tear when anxious Fancy paints
Upon his mind the image of the Maid,
The blue-eyed Maid who died beneath thy surge.
Where yon dark cliff † o'ershadows the blue main,
Theora died amidst the stormy waves,
And on its feet the sea-dews wash'd her corpse,
And the wild breath of storms shook her black locks.
Young was Theora; bluer was her eye
Than the bright azure of the moonlight night;
Fair was her cheek as is the ocean cloud
Red with the morning ray.
Amidst the groves,
And greens and nodding rocks that overhang
The grey Killarney, pass'd her morning days
Bright with the beams of joy.
To solitude,
To Nature, and to God, she gave her youth;

* The Islands of Scilly.

† A Rock near the Land's End, called the 'Irish Lady.'

Hence were her passions tuned to harmony.
Her azure eye oft glisten'd with the tear
Of sensibility, and her soft cheek
Glow'd with the blush of rapture. Hence, she loved
To wander 'midst the green-wood, silver'd o'er
By the bright moonbeam. Hence, she loved the rocks
Crown'd with the nodding ivy, and the lake
Fair with the purple morning, and the sea
Expansive mingling with the arched sky.
Kindled by Genius, in her bosom glow'd
The sacred fire of Freedom. Hence, she scorn'd
The narrow laws of custom that control
Her feeble sex. Great in her energies,
She roam'd the fields of Nature, scann'd the laws
That move the ruling atoms, changing still,
Still rising into life. Her eagle eye,
Piercing the blue immensity of space,
Held converse with the lucid sons of Heaven,
The day-stars of creation, or pursued
The dusky planets rolling round the Sun,
And drinking in his radiance light and life.
Such was the Maiden! Such was she who fled
Her native shores.
Dark in the midnight cloud,
When the wild blast upon its pinions bore
The dying shrieks of Erin's injured sons,*
She 'scaped the murderer's arm.
The British bark
Bore her across the ocean. From the West
The whirlwind rose, the fire-fraught clouds of Heaven
Were mingled with the wave. The shatter'd bark
Sunk at thy feet, Bolerium, and the white surge
Closed on green Erin's daughter.

* The Irish Lady was shipwrecked at the Land's End, about the time of the massacre of the Irish Protestants by the Catholics, in the reign of Charles the First.

That the Genius who presided over the destinies of Davy should have torn him from these flowery regions of Fancy, and condemned him to labour in the dusky caverns of the mineral kingdom, has furnished a fruitful theme of lamentation to the band of Poets, and to those who prefer the amusements to the profits of life, and who cherish the hallucinations of the imagination rather than the truths of science. If, however, we regret that Davy's Muse, like Proserpine, should have been thus violently seized, and carried off to the lower regions, as she was weaving her native wild flowers into a garland, we may console ourselves in knowing that, like the daughter of Ceres, she also obtained the privilege of occasionally revisiting her native bowers; for it will appear in the course of these memoirs, that in the intervals of more abstruse studies, Davy not unfrequently amused himself with poetical composition. But, in sober truth, is it possible that any reasonable being can regret the course in which he has been impelled? A great poetic Genius has said, "If Davy had not been the first Chemist, he would have been the first Poet of his age." Upon this question I do not feel myself a competent judge: but where is the modern Esau who would exchange his Bakerian Lecture for a poem, though it should equal in design and execution the PARADISE LOST?

As far as can be ascertained, one of the first original experiments in Chemistry performed by him at Penzance, was for the purpose of discovering the quality of the air contained in the bladders of sea-weed, in order to obtain results in support of a favourite theory of light; and to ascertain whether, as land vegetables are the renovators of the atmosphere of land-animals, sea-vegetables might not be the preservers of the equilibrium of the atmosphere of the ocean. From these experiments he concluded, that the different orders of the marine *Cryptogamia* were capable of decomposing water, when assisted by the attraction of light for oxygen.

His instruments, however, were of the rudest description, manufactured by himself out of the motley materials which chance threw in his way; the pots and pans of the kitchen, and even the more sacred vessels and professional instruments of the surgery, were without the least hesitation or remorse put in requisition.

While upon this subject, I will relate an anecdote which was communicated to me by my late venerable friend Mr. Thomas Giddy.* A French

* I cannot allude to this name, without paying a tribute of respect to the memory of one who, for more than half a century, practised the profession of a surgeon in Penzance with as much credit to himself, as advantage to his neighbourhood.

vessel having been wrecked off the Land's End, the surgeon escaped, and found his way to Penzance; accident brought him acquainted with Humphry Davy, who showed him many civilities, and in return received, as a present from the surgeon, a case of instruments which had been saved from the ship. The contents were eagerly turned out and examined by the young chemist, not, however, with any professional view as to their utility, but in order to ascertain how far they might be convertible to experimental purposes. The old-fashioned and clumsy glyster apparatus was viewed with exultation, and seized in triumph!—What reverses may not be suddenly effected by a simple accident! so says the moralist. Reader, behold an illustration:—in the brief space of an hour, did this long-neglected and unobtrusive machine, emerging from its obscurity and insignificance, figure away in all the pomp and glory of a complicated piece of pneumatic apparatus: nor did its fortunes end here; it was destined for greater things; and we shall hereafter learn that it actually performed the duties of an air-pump, in an original experiment on the nature and sources of heat. The most humble means may certainly accomplish the highest ends: the filament of a spider's web has been used to measure the motions of the stars; and a kite, made with two cross sticks and a silk handkerchief, enabled the chemical Prometheus to rob the thunder-cloud of its lightnings; but that a worn-out instrument, such as has been just described, should have furnished him who was born to revolutionize the science of the age, with the only means of enquiry at that time within his reach, affords, it must be admitted, a very whimsical illustration of our maxim.

Nor can we pass over these circumstances, without observing how materially they must have influenced the subsequent success of Davy as an experimentalist. Had he, at the commencement of his career, been furnished with all those appliances which he enjoyed at a later period, it is more than probable that he might never have acquired that wonderful tact of manipulation, that ability of suggesting expedients, and of contriving apparatus, so as to meet and surmount the difficulties which must ever beset the philosopher in the unbeaten tracts of Science. In this art, Davy certainly stands unrivalled, and, like his prototype Scheele,* or that pioneer of pneumatic experi-

* Bergman, Professor of Upsal, was informed of a young man who resided in the house of an apothecary, and who was reproached for neglecting the duties of his profession, while he devoted the whole of his time to Chemistry. Bergman's curiosity was excited; he paid him a visit, and was astonished at the knowledge he displayed, and at the profound researches in which he

mentalists, Dr. Priestley,* he was unquestionably indebted for his address to the circumstances above related. There never, perhaps, was a more striking exemplification of the adage, that " necessity is the parent of invention."

It would however appear that, imperfect as must have been his apparatus, and limited as were his resources, his ambition very early led him to the investigation of the most abstruse and recondite phenomena. He was not more than seventeen when he formed a strong opinion adverse to the general belief in the existence of *caloric*, or the materiality of heat.

As I shall hereafter have occasion to draw a parallel between the intellectual qualities of Davy, and those of the celebrated Dr. Black, the father of modern chemistry, it may not be irrelevant to state, in this place, that the subject of heat was also amongst the first that attracted the attention of this latter philosopher; indeed, he tells us himself, that he " can scarcely remember the time, when he had not some idea of the disagreement of facts with the commonly received doctrines upon this subject." The tendency of his mind, however, was in direct opposition to that of Davy's, for he insisted upon the materiality of heat, and was the first to conceive the bold idea of its being capable, like any other substance, of entering into chemical combination with various bodies, and of thus losing its characteristic qualities.

Black's theory could not be more opposed to that of Davy than was his conduct upon the occasion; for, although an experiment suggested itself to his mind, by which, as he thought, he could at once establish the truth of his favourite doctrine, he delayed performing it, because there did not happen to be an ice-house in the town in which he lived. With Davy, on the other hand, the conception and execution of an experiment were nearly simultaneous; no sooner, therefore, had he formed his opinion, than his eager spirit urged him to put it to the test.

Having procured a piece of clock-work, so contrived as to be set to work in an exhausted receiver, he added two horizontal plates of brass; the upper

was engaged, notwithstanding the poverty under which he laboured, and the restraint under which his situation placed him. He encouraged his ardour, and made him his friend. This young man was the celebrated *Scheele.*

* No man ever entered upon an undertaking with less apparent means of success, than did Priestley upon that of Chemistry. He neither possessed apparatus, nor the money to procure it. These circumstances, which, at first sight, seem so adverse, were in reality those which contributed to his ultimate success. The branch of Chemistry he selected was new; an apparatus had to be invented before any important step could be taken; and as simplicity is essential in every research, he was likely to contrive the best whose circumstances obliged him to attend to economy.

one carrying a small metallic cup, to be filled with ice, revolved in contact with the lower one. The whole machine, resting on a plate of ice, was covered by a glass receiver, and the air was exhausted by the very syringe, ingeniously modified for the purpose, with which the reader has already been made acquainted; for, as yet, he had no air-pump, and, what is still more worthy of notice, had never even seen one! The machine was now set in motion, when the ice in the small cup was soon observed to melt; whence he inferred that this effect could alone proceed from vibratory motion, since the whole apparatus was insulated from all accession of material heat, by the frozen mass below, and by the vacuum around it.

The experiment was afterwards repeated with greater care, and by means of a more refined apparatus; it was modified in different ways; and the results were ultimately published in an Essay, to be hereafter noticed, "On Heat, Light, and the Combinations of Light," which appeared in a provincial collection of tracts, edited by Dr. Beddoes, at Bristol.

Mr. Davies Gilbert, in describing the above experiment in his late address to the Royal Society, very justly observed that it does not at all decide the important matter in dispute, with respect to an ethereal or transcendental fluid; but that few young men remote from the society of persons conversant with science, will present themselves, who are capable of devising any thing so ingenious.

Dr. Henry, in a paper published in the "Memoirs of the Manchester Society," on entering into a review of this and similar experiments, very truly states, that the mode of insulation is not only imperfect, but that, according to Count Rumford, caloric will even pass through a Torricellian vacuum.

The most prominent circumstance in the history of this period of Davy's life, is his introduction to Mr. Davies Giddy, now Mr. Gilbert, the present distinguished and popular President of the Royal Society. The manner in which this happened is as curious as its result was important; and it furnishes another very striking illustration of the power of simple accident in directing our destinies. Mr. Gilbert's attention was attracted to the future philosopher, as he was carelessly swinging over the hatch, or half gate, of Mr. Borlase's house, by the humorous contortions into which he threw his features. Davy, it may be remarked, when a boy, possessed a countenance which, even in its natural state, was very far from comely, while his round shoulders, inharmonious voice, and insignificant manner, were calculated to produce any thing rather than a favourable impression: in riper years, he was what might be called "good-looking," although, as a wit of the day observed, his aspect was certainly of the "Bucolic" character. The change which his person underwent, after his promotion to the Royal Institution, was so rapid, that, in the days of Herodotus, it would have been attributed to nothing less than the miraculous interposition of the Priestesses of Helen. A person, who happened to be walking with Mr. Gilbert upon the occasion alluded to, observed that the extraordinary-looking boy in question was young Davy, the Carver's son, who, he added, was said to be fond of making chemical experiments. "Chemical experiments!" exclaimed Mr. Gilbert, with much surprise, "if that be the case, I must have some conversation with him." Mr. Gilbert, as we all know, possesses a strong perception of character, and he therefore soon discovered ample evidence of the boy's singular genius. After several interviews, which confirmed him in the opinion he had formed, he offered young Humphry the use of his library, or any other assistance that he might require for the pursuit of his studies; and at the same time gave him an invitation to his house at Tredrea, of which Davy frequently availed himself.

During one of his visits, Mr. Gilbert accompanied him to Hayle Copper-House, and introduced him to Dr. Edwards, a gentleman afterwards known to the medical profession as the chemical lecturer in the school of St. Bartholomew's Hospital; at the time, however, alluded to, he resided at Copper-House with his father, and possessed a well-appointed laboratory. The tumultuous delight which Davy expressed on seeing, for the first time, a quantity of chemical apparatus, hitherto only known to him through the medium of engravings, is described by Mr. Gilbert as surpassing all description. The air-pump more especially fixed his attention, and he worked its piston, exhausted the receiver, and opened its valves, with the simplicity and joy of a child engaged in the examination of a new and favourite toy.

It is a curious circumstance, that the phenomena resulting from the contact of iron and copper, in the investigation of which Davy was destined to perform so prominent a part, were very early noticed by Mr. Edwards in this place; who found that the flood-gates in the Port of Hayle decayed with a rapidity wholly inexplicable, but upon the supposition of some *chemical* action between the metals which had not yet been clearly explained. How little did Mr. Edwards imagine that the fact, which had so powerfully excited his curiosity, would become to the youth before him, a future source of rich and honourable discovery!

During the following year, an event occurred which contributed, in no small degree, to the advancement of Davy's prospects. Mr. Gregory Watt, who had long been in a declining state of health, was recommended by his physicians to reside for some time in the West of England, and he accordingly proceeded at once to Penzance, and took up his abode, as a lodger and boarder, in the house of Mrs. Davy. It may be supposed that two kindred spirits would not be long in contracting an acquaintance with each other; in fact, an intimacy of the warmest nature did ultimately grow up between them, and continue to the very moment of Mr. Watt's premature dissolution; the origin and progress of their friendship, however, are too curious to be passed over without some notice.

Mr. Gregory Watt possessed a warm and affectionate heart, but there was a solemn, aristocratic coldness in his manner, which repulsed every approach to familiarity. Davy, it has been already stated, did not possess any of those qualifications, in person or manner, which are calculated to produce favourable prepossessions. It may, therefore, be readily imagined how Mr. Watt must have felt, on finding the son of his landlady familiarly addressing him on subjects of metaphysics and poetry. By one of those strange perversions which have so frequently led great men to conceal the peculiarity of their talents, and to rest their claims to notice and respect upon qualifications which they possessed only in an inferior degree, Davy sought to ingratiate himself with Mr. Watt by metaphysical discussions; but, instead of admiration, he excited the disgust of his hearer. It was by mere accident that an allusion was first made to chemistry, when Davy flippantly observed, that he would undertake to demolish the French theory in half an hour;—he had touched the chord,—the interest of Mr. Watt was excited,—he conversed with Davy upon his chemical pursuits,—he was at once astonished and delighted at his sagacity,—the barrier of ice was removed, and they became attached friends.

Mr. Wedgwood, and his brother Thomas, also spent a winter at Penzance; and I have reason to believe that their friendship was of substantial benefit to Davy.

Before I attend the progress of our philosopher to the next scene of life, or proceed to detail the circumstances connected with his departure from Penzance, I must relate the following anecdote. Until the formation of the Geological Society of London occasioned the introduction of more extended and sounder views into the science, geologists were divided into two great rival sects, — into Neptunists and Plutonists; the one affirming that the globe was exclusively indebted for its present form and arrangement to the agency of water, the other, admitting to a certain extent the operation of water, but maintaining the utter impossibility of explaining the consolidation of the strata without the intervention of fire. Every geologist felt bound to side with the one or the other of these contending parties, for neutrality was held as disgraceful as though the law of Solon had been in active operation. I shall not easily forget the din and the fury of this elemental war, as it raged in Edinburgh when I was a student in that University; even the mineral dealers, who, like the artisans of a neutral city, sold arms and ammunition to both sides, still defended their own opinions with party fury. It was amusing to observe the triumph and dismay which, by turns, animated and depressed each side, as the discovery of a new fact, or a fresh specimen, appeared to give a preponderance to the doctrine of fire or water. The fact of so large a portion of the strata being found in the state of a carbonate was advanced by the Neptunists as an unanswerable argument against igneous agency; the dismay therefore which this sect received upon the discovery of Sir James Hall, that under the combined forces of heat and compression, carbonate of lime might be fused, was only equalled by the excessive joy excited in the contending party. We may form some notion of the high importance attached to this discovery, when we learn that its author applied to the Government for a flag of truce to convey illustrative specimens to the Continental philosophers.

It so happened, that the Professors of Oxford and Cambridge ranged themselves under opposite banners: Dr. Beddoes was a violent and uncompromising Plutonist, while Professor Hailstone was as decided a Neptunist. The rocks of Cornwall, and their granitic veins, had been appealed to, as affording evidence upon the subject; and the two Professors, who, although adverse in opinion, were united in friendship, determined to proceed together to the field of dispute, each hoping that he might thus convince the other of his error, and cure him of his heresy. The belligerents arrived at Penzance, and in company with their mutual friend, Mr. Davies Gilbert, examined the coast, and procured specimens with pretty much the same spirit of selection as a schoolboy consults his Gradus, not for an epithet of any meaning, but for one which best suits his measure; and having made drawings, disputed obvious appearances, rendered that which was clear to the senses, confused to the understanding, and what was already confused, ten times more obscure, they returned, the opinion of each, as might easily have been anticipated, having been strengthened by the ordeal; the one protesting that the very aspect of the shivered slate was sufficient to prove that the globe must have been roasted to rags; the other, with equal plausibility, declaring that there was not a tittle of evidence to show that the watery solvent had ever even simmered. Such, in fact, must ever be the case, when philosophers view the same subject under such different impressions, and in such opposite points of view; like the two knights who could not agree respecting the colour of the shield, only because each saw a different side of it.

Rocks, it is said, have flinty hearts, and certain it is that, upon this occasion, Cornwall did not afford that assistance against the Neptunists, which the Oxford Professor had sought with so much zeal and confidence; but if deferred revenge had, as we are told is generally the case, been put out at compound interest, and Beddoes had exacted its dues with more than judaical rigour, it must be allowed that Cornwall, by placing Davy at his disposal, would have fully cancelled all demands.

> Plutonian Beddoes, erst, in spiteful ire,
> To see a *Hailstone* mock his central fire,
> A mighty Spirit raised, by whose device
> We now burn HAILSTONES, and set fire to ICE.

Before quitting this subject, it is but justice to advert to the progress which Geology has made since the turbulence of this contest has subsided; it has grown strong in facts, and is daily increasing its stores. It has been wisely said by one of the ancient Poets, that in vehement disputes, not only the persons engaged, but every one who is at all interested, must suffer; not only the combatants, but the spectators of the combat,—for it is difficult to apprehend truth while it is the subject of angry contest.

To return to the narrative.—Upon Beddoes establishing the "Pneumatic Institution" at Bristol, he required an assistant who might superintend the necessary experiments in the laboratory; and Mr. Gilbert proposed Davy as a person fully competent to fill the situation. The young candidate had already produced a very favourable impression upon Dr. Beddoes, by his experiments upon Heat and Light, which he had some time before transmitted to him through the hands of his friend Mr. Gregory Watt. This fact may be collected from a note appended by Dr. Beddoes to Davy's paper subsequently published in the first volume of the West Country Contributions, in which the Doctor says, "My first knowledge of Mr. Davy arose from a letter written in April 1798, containing an account of his researches on Heat and Light."

The rest is told in the letters which passed on this occasion between Dr. Beddoes and Mr. Gilbert, and from which I shall make such extracts as may be necessary to complete the history of a transaction of much interest and importance.

In a letter dated July 4, 1798, Dr. Beddoes says, "I am glad that Mr. Davy has impressed you as he has me. I have long wished to write to you about him, for I think I can open a more fruitful field of investigation than any body else. Is it not also his most direct road to fortune? Should he not bring out a favourable result, he may still exhibit talents for investigation, and entitle himself to public confidence more effectually than by any other mode. He must be maintained, but the fund will not furnish a salary from which a man can lay up any thing. He must also devote his time for two or three years to the investigation. I wish you would converse with him upon the subject. No doubt he has received my two last letters. I am sorry I cannot at this moment specify a yearly sum, nor can I say with certainty whether all the subscribers will accede to my plan; most of them will, I doubt not. I have written to the principal ones, and will lose no time in sounding them all."

In a second letter of the 18th of July, we find the following observations. "I have received a letter from Mr. Davy since I wrote to you. He has oftener than once mentioned a *genteel maintenance*, as a preliminary to his being employed to superintend the Pneumatic Hospital. I fear the funds will not allow an ample salary; he must, however, be maintained. I can attach no idea to the epithet *genteel*, but perhaps all difficulties would vanish in conversation; at least, I think your conversing with Mr. Davy will be a more likely way of smoothing difficulties, than our correspondence. It appears to me, that this appointment will bear to be considered as a part of Mr. Davy's medical education, and that it will be a great saving of expense to him. It may also be the foundation of a lucrative reputation; and certainly nothing on my part shall be wanting to secure to him the credit he may deserve. He does not undertake to discover cures for this or that disease; he may acquire just applause by bringing out clear, though negative results. During my journeys into the country, I have picked up a variety of important and curious facts from different practitioners. This has suggested to me the idea of collecting and publishing such facts as this part of the country will, from time to time, afford. If I could procure chemical experiments, that bore any relation to organised nature, I would insert them. If Mr. Davy does not dislike this method of publishing his experiments, I would gladly place them at the head of my first volume, but I wish not that he should make any sacrifice of judgment or inclination."

It remains only to be stated, that Mr. Gilbert kindly undertook the negotiation, and completed it to the satisfaction of all the principal parties. Mrs. Davy yielded to her son's wishes, and Mr. Borlase very generously surrendered his indenture, with an endorsement to the following effect,—that he freely gave up the indenture, on account of the singularly promising talents which Mr. Davy had displayed.

His old and valued friend Mr. Tonkin, however, not only expressed his disapprobation of this scheme, but was so vexed and irritated at having his favourite plan of fixing Davy in his native town as a Surgeon, thus thwarted, that he actually altered his will, and revoked the legacy of his house which he had previously bequeathed him. Mr. Tonkin died on the 24th of December 1801; so that, although he lived long enough to witness Davy's appointment to the Royal Institution, he could never have anticipated the elevation to which his genius and talents ultimately raised him.

On the 2nd of October, in the year 1798, Davy quitted Penzance, before he had attained his twentieth year. Mr. Gilbert well remembers meeting him upon his journey to Bristol, and breakfasting with him at Okehampton, on the 4th of October. He was in the highest spirits, and in that frame of mind in which a man of ardent imagination identifies every successful occurrence with his own fortunes; his exhilaration, therefore, was not a little heightened by the arrival of the mail-coach from London, covered with laurels and ribbons, and bringing the news, so cheering to every English heart, of NELSON's glorious victory of the NILE.

CHAPTER II.

Cursory thoughts on the advantages of Biography.—Plan and objects of the Pneumatic Institution.—Davy contracts friendships during his residence at Bristol.—His first visit to London.—His Letters to Mr. Davies Gilbert.—The publication of the West Country Contributions, by Dr. Beddoes.—Davy's Essays on Heat, Light, and Respiration.—His interesting experiments on bonnet canes.—He commences an enquiry into the nature of nitrous oxyd.—He publishes his chemical researches.—A critical examination of the work.—Testimony of Tobin, Clayfield, Southey, and others, respecting the powers of nitrous oxyd.—Davy breathes carburetted hydrogen gas, and nearly perishes from its effects.—His new Galvanic experiments communicated in a Letter to Mr. Gilbert.

Having concluded the early history of the subject of these memoirs, and conducted it to that memorable day on which he left his native town, and bursting from obscurity, prepared to enter upon a wider field of usefulness and honour, I shall accompany him in his progress; and with the honest desire of affording instruction as well as amusement,—for history is useful only as it holds up the mirror of Truth,—I shall continue to point out the various circumstances that may have contributed to his success and scientific renown; and to offer such occasional reflections as may be likely to illustrate not only the superficial peculiarities which constitute the light and shade of character, but those deeper varieties of mind, upon which the superiority of intellect may be supposed to depend.

After all, the great end of biography is not to be found, as some would seem to imagine, in a series of dates, or in a collection of gossiping anecdotes and table-talk, which, instead of lighting up and vivifying the features, hang as a cloud of dust upon the portrait; but it is to be found in an analysis of human genius, and in the developement of those elements of the mind, to whose varied combinations, and nicely adjusted proportions, the mental habits, and intellectual peculiarities of distinguished men may be readily referred.

It has been stated that an arrangement had been concluded between Dr. Beddoes and Davy: it is but an act of justice to say, that it was of a liberal and honourable description; and let me also add, in this place, that no sooner had Davy found himself in a situation which secured for him the necessaries of life, than he renounced all claims upon his paternal property, in favour of his mother and sisters.

By acceding to the proposal of Dr. Beddoes, Davy never intended to abandon the profession in which he had embarked; on the contrary, he persevered in his determination to study and graduate at Edinburgh, and his patron promised that every opportunity should be afforded him at Bristol, for seeing medical practice: this part of the arrangement, however, was voluntarily abandoned by him, for he soon became so absorbed by the labours of the laboratory, as to leave little leisure for the clinical studies of the hospital.

The Pneumatic Institution was established for the purpose of investigating the medical powers of factitious airs or gases; and to Davy was assigned the office of superintending the various experiments.

It is now generally acknowledged, that the Art of Physic has not derived any direct advantage from the application of a class of agents which, undoubtedly, held forth the fairest promise of benefit; but it is too frequently the case, that in physic, theory and experience are in open hostilities with each other. The gases are now never employed in the treatment of disease, except by a few crafty or ignorant empirics, whose business it is to enrich themselves by playing on the credulity of mankind: indeed, we may say of popular remedies in general what M. de Lagrange has so wittily said of popular prejudices, that they are the cast-off clothes of philosophers, in which the rabble dress themselves.

The investigation, however, into the nature and composition of the gases paved the way to some new and important discoveries in science; so that, to borrow a Baconian metaphor, although our philosophers failed in obtaining the treasure for which they so eagerly dug, they at least, by turning up and pulverizing the soil, rendered it fertile. The ingenuity of the chemist will for ever remain on record; the phantoms of the physicians have vanished into air.

Davy was now constantly engaged in the prosecution of new experiments, in the conception of which, as he himself informs us, he was greatly aided by the conversation and advice of Dr. Beddoes. He was also occasionally assisted by Mr. William Clayfield, a gentleman ardently attached to chemical pursuits, and whose name is not unknown in the annals of science; indeed, it appears that to him he was indebted for the invention of a mercurial air-holder, by which he was enabled to collect and measure the various gases submitted to examination. He had also the advantages of some society of a highly intellectual cast: it is sufficient to mention the names of Edgeworth and James Tobin.

In reply to a letter of enquiry which was lately addressed to her, Miss Edgeworth observes, that "her father possessed much influence over Davy's mind;" and that "when he was a very young man at Clifton, unknown to fame, Mr. Edgeworth early distinguished and warmly admired his talents, and gave him much counsel, which sunk deep into his mind."

The present Lord Durham and his brother were also resident in the house of Dr. Beddoes, not only for their education, but for the benefit of his professional superintendence. Besides those who were residing at Clifton, the most distinguished in the circles of science and literature paid passing visits to Dr. Beddoes; with many of whom Davy contracted an acquaintance, with some an intimacy, and with a few a solid and permanent friendship. In examining the individuals composing this latter class, we find them differing so widely from each other in character and pursuit, that we are led to enquire upon what principles of affinity his regards could possibly have been attracted —the truth is, that there was more than one avenue to his heart; and the philosopher, the poet, the physician, the philanthropist, and the sportsman, found each, upon different terms, a more or less ready access to its recesses. The chemist who would aspire to his favour, could alone obtain it by laborious application and novel research; the philanthropist, by the practicability of his schemes for improving society, and increasing the sum of its happiness; but the fisherman instantly caught his affections by a hook and line. To be a fly-fisher was, in his opinion, to possess the capabilities of intellectual distinction, although circumstances might not have conspired to call them into action; whilst a proficiency in this art, when exhibited by an individual otherwise distinguished, gave him an additional claim to his attention and regard. The stern courage of Nelson, tempered as it was with all the kindly feelings of humanity, was sufficient to excite in the breast of Davy the most enthusiastic admiration; but the circumstance of his having been a fly-fisher, and continued the sport, even with his left hand, threw, in his opinion, a still brighter halo around his character.

No one who knew him can accuse him of inconstancy in his friendships: amidst the excitements of his station, and the abstractions incident to his pursuits, he might not always have shown those little attentions which are received by the world as the indications of personal regard; but his heart beat not less warmly on that account: when the flame of affection had been once kindled, it burnt with a pure and steady light through life. This will be readily seen in the letters addressed to his several early friends, more especially to Mr. Poole of Nether Stowey, in Somersetshire, and to Mr. Clayfield of Bristol, from which I shall have occasion to present some interesting extracts.

Those who had become acquainted with Davy in early life, and were enabled to watch the whole progress of his career from obscurity to the highest pinnacle of fame, have declared that his extraordinary talents never at any period excited greater astonishment and admiration than during his short residence at Bristol. His simplicity of mind and manner was also at this time truly delightful. He scarcely knew the names of our best authors, and had much less read any of their works; and yet upon topics of moral philosophy and metaphysics he would enter into discussion with acknowledged scholars, and not only delight them with the native energy of his mind, but instruct them by the novelty and truth of his conceptions. Mr. Coleridge lately expressed to me the astonishment he felt, very shortly after his introduction to him, on hearing him maintain an argument upon some abstruse subject with a gentleman equally distinguished for the extent of his erudition, and for the talent of rendering it available for illustration;—the contrast was most striking—it was the fresh and native wild flower, opposed to the elaborate exotic of the *Hortus Siccus!*

During this period, he occasionally visited his friend Mr. Gregory Watt, at Birmingham; at which place his ambition was constantly excited by intercourse with congenial minds; and his letters to his mother and relations represent him as rejoicing in the success of his experiments, and as delighting in his association with kindred genius; but always casting a longing, lingering thought on the scenes of his boyhood, he spoke with joyful anticipation of the period at which he proposed to revisit his mother and family.

That he still continued to regard the practice of physic as the great end and object of all his pursuits, is evident from one of these letters, written in 1799, in which he says, "Philosophy, Chemistry, and Medicine, are my profession."

On the 1st of December 1799 he visited London for the first time, and remained about a fortnight; the friends with whom he associated upon this occasion were Coleridge, Southey, Gregory Watt, Underwood, James and

John Tobin, Thomson, and Clayfield; all of whom vied with each other in their exertions to render his visit agreeable, conducting him to such persons and places as were deemed worthy of his notice.

Of all the letters placed at my disposal, those addressed to his early friend and patron, Mr. Davies Gilbert, are, in my judgment, the most interesting: it is true, that as specimens of epistolary style they have but slender pretensions, and are far less pleasing than those written to Mr. Poole and others, in later life; but let it be remembered that, as yet, their writer had never enjoyed the advantages of literary correspondence. For the defects, however, of style, there is more than sufficient compensation; they speak from the heart;—they carry with them internal evidence of the honest simplicity of his mind, and they throw a light upon the peculiarities of his genius, which without such aid might be less perfectly understood; above all, they evince an ardour which no difficulties could repress, and a confidence which no failures could extinguish. We clearly discern from his first letters, that he entered upon his career of experiment with an almost chivalrous feeling, flushed with the consciousness of native strength, and exulting in the prospect of destined achievements.

I am aware that there are those who still object, with Dr. Sprat, to the practice of publishing letters which were never intended for the public eye, and I experience the inconvenience, while I respect the delicacy, of such an opinion. I confess, on my own part, I have always considered, with Mr. Mason, that the objections urged by the learned historian of the Royal Society are wholly untenable. He talks of "the souls of men thus appearing undressed, or in a habit too negligent to go abroad in the streets, although they might be seen by a few in a chamber." But the undress he would condemn, is the nakedness of Truth—the negligent attire, the simple and unadorned expression of those natural and significant traits, whose value incomparably exceeds the premeditated and artificial exhibitions of mind and manner. "*Nam in ingenio quoque sicut in agro, quanquam alia diu serantur atque elaborantur, gratiora tamen quæ sua sponte nascuntur.*" *

I cannot but suspect that Dr. Sprat was, upon this occasion, more anxious to display a metaphor, than to illustrate a truth; I have often thought a very curious book might be written to show how greatly, both in physics and in morals, the progress of truth has been retarded, and the judgment of men warped, by the abuse of metaphors; the most correct of which can be nothing more than

* Dialogus de Oratoribus.—*Tacit.*

the image of Truth reflected, as it were, from a mirror, and consequently liable to all the delusions of our mental optics. The figure by which Nature was represented as "*abhorring a vacuum,*" kept us in ignorance of the true theory of the pump for two thousand years after the discovery of the weight, or gravity, of the atmosphere;* and the unfortunate P. L. Courier positively owed his conviction to a metaphor in the Judge's charge—"*Un écrit plein de poison.*"—Well might the defendant exclaim, "*Sauvez-nous de la Metaphore!*"

The first of the letters to which I have alluded appears to have been written rather more than five weeks after his arrival at Clifton.

TO DAVIES GIDDY, ESQ.

Clifton, November 12, 1798.

DEAR SIR,

I HAVE purposely delayed writing until I could communicate to you some intelligence of importance concerning the Pneumatic Institution. The speedy execution of the plan will, I think, interest you, both as a subscriber and a friend to science and mankind. The present subscription is, we suppose, nearly adequate to the purpose of investigating the medicinal powers of factitious airs; it still continues to increase, and we may hope for the ability of pursuing the investigation to its full extent. We are negotiating for a house in Dowrie Square, the proximity of which to Bristol, and its general situation and advantages, render it very suitable to the purpose. The funds will, I suppose, enable us to provide for eight or ten patients in the hospital, and for as many out of it as we can procure.

We shall try the gases in every possible way. They may be condensed by pressure and rarefied by heat. *Quere,*—would not a powerful injecting syringe,† furnished with two valves, one opening into an air-holder and the other into the breathing chamber, answer the purpose of compression better than any other apparatus? Can you not, from your extensive stores of philosophy, furnish us with some hints on this subject? May not the non-

* Plutarch, in expressing the opinion of Asclepiades upon this subject, represents him as saying, that the external air, *by its weight,* opened its way with force into the breast. Seneca also was acquainted with the weight and elastic force of the air; for he describes the constant effort by which it expands itself when it is compressed, and affirms that it has the property of condensing itself, and of forcing its way through all obstacles that oppose its passage.—Quæst. Nat. lib. v. c. v. and vi.

† Here the reader will recognise the force of early associations.

respirable gases furnish a class of different stimuli? of which the *oxy-muriatic acid gas* would stand the highest, if we might judge from its effects on the lungs; then, probably, *gaseous oxyd of azote*, and *hydrocarbonate*.

I suppose you have not heard of the discovery of the native *sulphate of strontian* in England. I shall perhaps surprise you by stating that we have it in large quantities here. It had long been mistaken for *sulphate of barytes*, till our friend Clayfield, on endeavouring to procure the *muriate of barytes* from it by decomposition, detected the strontian. We opened a fine vein of it about a fortnight ago, at the Old Passage near the mouth of the Severn. It was embodied in limestone and gypsum, the outside of the vein, a striated mass; the internal parts finely crystallised in cubes, of the Sp. Gr. 4·1. Clayfield has been working at it for some time. We have persuaded him to publish his analysis in the first volume of the Western Physical Collection.

I have made with him the phosphuret of barytes and of strontian; they possess, in common with that of lime, the property of producing phosphorized hydrogen gas; the phosphuret of strontian, it appears, in a more eminent degree.

We have likewise attempted to decompose the boracic and muriatic acids, by passing phosphorus, in vapour, through muriate, and borate of lime, heated red. Phosphate of lime was found in the experiment on the boracic acid, but, as no pneumatic apparatus was employed, the experiment was uncertain. We shall repeat them next week.

We are printing in Bristol the first volume of the 'West Country Collection,' which will, I suppose, be out in the beginning of January.

Mrs. Beddoes hopes that Miss Giddy received her letter, and desires me to certify that she wrote almost immediately after the reception of her epistle. She is as good, amiable, and elegant as when you saw her. Believe me, dear Sir, with affection and respect,

Truly your's,

HUMPHRY DAVY.

The work announced in the above letter was published in the commencement of the year 1799, under the title of "Contributions to Physical and Medical Knowledge, principally from the West of England; collected by Thomas Beddoes, M.D."

The first two hundred pages, constituting very nearly half the volume, are the composition of Davy, and consist of essays "On Heat, Light, and the

Combinations of Light." "On Phos-oxygen, or Oxygen and its Combinations;" and "On the Theory of Respiration."

His first essay commences with an experiment, in order to show that light is not, as Lavoisier supposed, a modification, or an effect, of heat, but matter of a peculiar kind, *sui generis*, which, when moving through space, or in a state of projection, is capable of becoming the source of a numerous class of our sensations.

A small gunlock was armed with an excellent flint, and, on being snapped in an exhausted receiver, did not produce any light. The experiment was repeated in carbonic acid, and with a similar result. Small particles were in each case separated from the steel, which, on microscopic examination, evidently appeared to have undergone fusion. Whence Davy argued, that light cannot be caloric in a state of projection, or it must have been produced in these experiments, where heat existed to an extent sufficient to fuse steel. Nor, that it can be, as some have supposed, a vibration of the imaginary fluid ether, for, granting the existence of such a fluid, it must have been present in the receiver. If then light be neither caloric in a state of projection, nor the vibration of an imaginary ether, it must, he says, be a substance *sui generis*.

With regard to caloric, his opinion that it is not, like light, material, has been already noticed. In the present essay he maintains the proposition by the same method of reasoning as that by which he attempts to establish the materiality of light, and which mathematicians have termed the *reductio ad absurdum*."

In his chapter on "Light and its Combinations," he indulges in speculations of the wildest nature, although it must be confessed that he has infused an interest into them which might almost be called dramatic. They are certainly highly characteristic of that enlightened fancy, which was perpetually on the wing, and whose flight, when afterwards tempered and directed by judgment, enabled him to abstract the richest treasures from the recesses of abstract truth.

Taking it for granted that caloric has no existence as a material body, or, in other words, that the phenomena of repulsion do not depend upon the agency of a peculiar fluid, and that, on the contrary, light is a subtle fluid acting on our organs of vision *only when in a state of repulsive projection*, he proceeds to examine the French theory of combustion; the defects of which he considers to arise from the assumption of the imaginary fluid *caloric*, and the total neglect of *light*. He conceives that the light evolved during combustion previously existed in the oxygen gas, which he therefore proposes for the future to call PHOS-OXYGEN.

In following up this question, he would seem to consider Light as the *Anima Mundi*, diffusing through the universe not only organization, but even animation and perception.

Phos-oxygen he considers as capable of combining with additional proportions of Light, and of thus becoming '*luminated Phos-oxygen!*' — from the decomposition of which, and the consequent liberation of light, he seeks to explain many of the most recondite phenomena in Nature.

We cannot but admire the eagerness with which he enlists known facts into his service, and the boldness with which he ranges the wilds of creation in search of analogies for the support and illustration of his views. He imagines that the *Phos-oxygen*, when thus *luminated*, must necessarily have its specific gravity considerably diminished by the combination, and that it will therefore occupy the higher regions of the atmosphere; hence, he says, it is that combustion takes place at the tops of mountains at a lower temperature than in the plains, and with a greater liberation of light. The hydrogen which is disengaged from the surface of the earth he supposes will rise until it comes into contact with this *luminated Phos-oxygen*, when, by its attracting the oxygen to form water, the light will be set free, and give origin to the phenomena of fiery meteors at a great altitude.

The phenomenon termed '*Phosphorescence*,' or that luminous appearance which certain bodies exhibit after exposure to heat, is attributed by this theory to the light, which may be supposed to quit such substances as soon as its particles have acquired repulsive motion by elevation of temperature.

The Electric Fluid is considered as Light in a condensed state, or, in other words, in that peculiar state in which it is not supplied with a repulsive motion sufficiently energetic to impart projection to its particles; for, he observes, that its chemical action upon bodies is similar to that of Light; and when supplied with repulsive motion by friction, or by the contact of bodies from which it is capable of subtracting it, it loses the projectile form, and becomes perceptible as Light. It is extremely probable, he adds, that the great quantity of this fluid almost everywhere diffused over our earth is produced by the condensation of Light, in consequence of the subtraction of its repulsive motion by black and dark bodies; while it may again recover the projectile force by the repulsive motion of the poles, caused by the revolution of the earth on its axis, and thus appear again in the state of sensible light; and hence the phenomenon of the *Aurora Borealis,* or Northern Lights.

In considering the theory of Respiration, he supposes that *phos-oxygen* combines with the venous blood without decomposition; but that, on reaching the brain, the light is liberated in the form of Electricity, which he believes to be identical with the nervous fluid. On this supposition, sensations and ideas are nothing more than motions of the nervous ether; or light exciting the medullary substance of the nerves and brain into sensitive action!

He thinks it would be worth while to try, by a very sensible electrometer, whether an insulated muscle, when stimulated into action, would not give indications of the liberation of electric fluid, although he suspects that in man the quantity is probably too small, and too slowly liberated to be ascertainable. In the torpedo, and in some other animals, however, it is unquestionably given out perceptibly during animal action.

When any considerable change takes place in the organic matter of the body, so as to destroy the powers of life, new chemical attractions and repulsive motions take place, and the different principles of which the body is composed enter into new combinations. In this process, which is called putrefaction, Davy, in pursuance of his theory, thinks that in land-animals the latent light of the system enters into new combinations with oxygen and nitrogen, but that in fish no such combinations occur, and hence the luminous appearance which accompanies their putrefaction.

Such is the outline of these extraordinary Essays. They stand upon record, and therefore, as a faithful biographer, I was bound to notice them; nor are they devoid of interest or instruction: I am not quite sure that, amidst all the meteors of his fancy, there may not be a gleam of truth. I allude to his theory of Respiration; it certainly does not square with the physiological opinions of the day; nor did that of Newton, when he conjectured that water might contain an inflammable element; but it was the refraction of a great truth, at that time below the horizon.

It was a very ancient opinion, that life, being in its own nature aëriform, is under the necessity of renewing itself by inspiring the air. Modern chemistry, by teaching us the nature of the atmosphere, has dispelled many fanciful theories of its action, but it has not yet explained why respiration, the first and last act of life,* cannot be suspended, even for a minute, without the

* Breath and life are synonymous. In the Greek, the most philosophically constructed language with which we are acquainted, this *first* and *last* act is expressed by a verb composed of

extinction of vitality. When we reflect upon this fact, it is scarcely possible not to believe that the function has been ordained for some greater purpose than that of removing a portion of carbon from the circulating blood. Is it unreasonable to conclude that some principle is thus imparted, which is too subtle to be long retained in our vessels, and too important to be dispensed with, even for the shortest period? "I offer this opinion," as Montaigne says, "not as being good, but as being my own."

By these observations, I am not to be supposed as wishing, for a moment, to uphold the wild hypotheses which I have just related; it must be admitted that the theory of *phos-oxygen* and *luminated phos-oxygen* has scarcely a parallel in extravagance and absurdity; and I happen to know that, in after life, Davy bitterly regretted that he had so committed himself; any allusion to the subject became a source of painful irritation. It is to be remarked, that in every course of lectures, although Davy did not refer to these theories, he frequently alluded to the unphilosophic spirit that had given origin to them; as if he had imposed upon himself this penance as an atonement for his early follies. The following note was taken at one of his lectures.—"After what has been said, it will be useless to enter upon an examination of any of those theories, which, assuming for their foundation the connexion of life with respiration, have attempted to prove that oxygen is the principle of life, and that the wonderful and mysterious phenomena of perception arise from the action of common gravitating substances upon each other. Such theories are the dreams of misemployed genius, which the light of experiment and observation has never conducted to truth, and are merely a collection of terms derived from known phenomena, and applied by loose analogies of language to unknown things."

The reader, however, will be disposed to treat him with all tenderness when he remembers that the author of these Essays was barely eighteen years of age. If blame is to fall on any one, let it fall on Dr. Beddoes, who never should have sanctioned the publication; had he curbed the ardent and untamed imagination of the young philosopher, he would have acted the part of a wise man and of a kind friend. But the truth is, that much as Davy needed the bridle, Beddoes* required it still more. He was as little fitted

alpha and omega—αω. In the Latin, the connexion between *spiro* and *spiritus*, breath and life, is evident.

* The only pun Davy is said to have ever made was upon the occasion of Mr. Sadler being

for a Mentor as a weathercock for a compass, and had it not been for the ascendency which Davy gained over his mind, the ardour of his temperament would have continually urged him beyond the bounds of reason.

Caught by the loosest analogies, he would arrive at a conclusion without examining all the conditions of his problem. In the exercise of his profession, therefore, he was frequently led to prescribe plans which he felt it necessary to retract the next hour. His friend Mr. T—— had occasion to consult him upon the case of his wife; the Doctor prescribed a new remedy; but, in the course of the day he returned in haste, and begged that, before Mrs. T—— took the medicine, its effect might be tried on a dog!

The following anecdote, which was lately communicated to me by Mr. Coleridge, will not only illustrate a trait of character, but furnish a salutary lesson to the credulous patron of empirics. As soon as the powers of nitrous oxide were discovered, Dr. Beddoes at once concluded that it must necessarily be a specific for paralysis. A patient was selected for the trial, and the management of it was entrusted to Davy. Previous to the administration of the gas he inserted a small pocket thermometer under the tongue of the patient, as he was accustomed to do upon such occasions, to ascertain the degree of animal temperature, with a view to future comparison. The paralytic man, wholly ignorant of the nature of the process to which he was to submit, but deeply impressed, from the representations of Dr. Beddoes, with the certainty of its success, no sooner felt the thermometer between his teeth than he concluded that the *talisman* was in full operation, and in a burst of enthusiasm declared that he already experienced the effects of its benign influence throughout his whole body—the opportunity was too tempting to be lost—Davy cast an intelligent glance at Mr. Coleridge, and desired the patient to renew his visit on the following day, when the same ceremony was again performed, and repeated every succeeding day for a fortnight, the patient gradually improving during that period, when he was dismissed as cured, no other application having been used than that of the thermometer. Dr. Beddoes, from whom the circumstances of the case had been intentionally concealed, saw in the restoration of the patient the confirmation of his opinion, and the fulfilment of his most ardent hope—Nitrous Oxide was a specific remedy for Paralysis! "It were criminal to retard the general promulgation of so important a dis-

appointed by Dr. Beddoes as his successor. "I cannot imagine," said he, "why he has engaged *Sadler*, unless it is that he may be well *bridled*."

covery; it were cruel to delay the communication of the fact until the publication of another volume of his '*Contributions*;' the periodical magazines were too slow in their rate of travelling; a flying pamphlet would be more expeditious; paragraphs in the newspapers; circulars to the hospitals:"—such were the reflections and plans which successively agitated the physician's mind, when his eyes were opened to the unwelcome truth by Davy's confessing the delusion that had been practised.

A short time after the publication of the first volume of the "Contributions," Davy addressed to his friend the following letter.

TO DAVIES GIDDY, ESQ.

Clifton, Feb. 22, 1799.

Dear Friend,—for I love you too well to call you by a more ceremonious name,—I have delayed writing to you from day to day, expecting that some of our experiments would produce results worthy of communication. Since I received your last very acceptable letter, I have been chiefly employed in pursuing the experiments on Heat, Light, Respiration, &c. Of these experiments I shall give you no account, as you will see them in print. I sent you a copy of my Essays last week; if you have not received them, I trust you will find them at my mother's, or at Mr. Tonkin's.

In the same parcel were two small packets, one from Mrs. Beddoes for your father, the other for Miss Giddy from Mrs. Willoughby. About a fortnight ago I sent a few chemical instruments to Mr. Penneck of Penzance; and inclosed with them were specimens of the different varieties of sulphate of strontian addressed to you. If you have not received them, you will get them by sending to Mr. Penneck.

On looking over a box of minerals last week, which was sent to Dr. Beddoes from Cumberland, I found two very fine specimens of sulphate of strontian, marked by the collector *Laminated Shorl.* I suspect this mineral is not scarce in calcareous countries; it is, I dare say, often mistaken for sulphate of barytes.

I have succeeded in combining strontian with the oxygenated muriatic acid. This salt possesses most astonishing properties;* you will find an account of them in my Essay.

* The following is the account given in his Essay. "When sulphuric acid was poured into a solution of this salt in water, a beautiful and unexpected phenomenon took place. The room was accidentally darkened at the moment this experiment was made, so that we were enabled to perceive a vivid luminous appearance. This experiment, independent of its beauty, is extremely pleasing as

When you have perused my papers, I shall be very much obliged to you for a criticism upon them. When I left Penzance, I was quite an infant in speculation, I knew very little of Light or Heat. I am now as much convinced of the non-existence of caloric, as I am of the existence of light. Independent of the experiments which appear to demonstrate its non-existence directly, and of which you will find an account in my Essay, the consideration of certain phenomena lead me to suppose that there would be no difficulty in proving its non-existence by reasoning. These considerations have occurred to me since the publication of the work. I could now render it much more perfect, but I hope soon to complete the investigation of the combinations of Light, and to produce a much more perfect work on the subject. I shall be infinitely obliged to you for any hints or observations, as far as the detection of errors of any kind, for it is no flattery to say that I pay greater deference to your opinion than to that of any other philosopher.

We intend next week to endeavour to ascertain, by the aid of a delicate balance, the quantities of Light liberated in different combustive processes. That there is a deficiency of weight, I am convinced from many experiments.

The experiments on Light, &c. have prevented me from attempting the decomposition of the undecompounded acids. We have ordered an apparatus at the glass-house for this purpose, and I hope next week we shall be able to carry on the investigation. Two modes of effecting these decompositions have occurred to me —first, to bring phosphorus or sulphur, in the gaseous state, in contact with the acid gases in a tube heated intensely. Secondly, to send sulphur in the gaseous state through muriate of copper or lead, heated white. The attraction of sulphur for oxygen, of copper for oxygen, and of sulphur for copper, will probably effect the decomposition.

Our laboratory in the Pneumatic Institution is nearly finished, and we shall begin the investigations in about a fortnight. We shall begin by trying the gases in their simplest mode of application, and gradually carry on the more complex processes.

I hope the gaseous oxide of azote will prove to be a specific stimulus for the absorbents.

affording an instance of true combustion, that is, the production of Light and Heat by the mixture of two incombustible bodies." It may be presumed, that this phenomenon arose from the developement and decomposition of a portion of Euchlorine, a compound which he subsequently discovered in 1811. In the year 1813, Chevreul announced, as a new discovery, that if strontian be heated in contact with muriatic acid gas, the gas is absorbed, and the earthy salt becomes red hot.—*See Annals of Philosophy,* vol. ii. p. 312.

I was last week surprised by a letter from Mr. Watt, announcing the success of their trial. When I was at Birmingham five weeks ago, the family were in very low spirits. I spent nine or ten days there, chiefly with Mr. Keir and Mr. Watt: I had a great deal of chemical conversation with them. Mr. Keir is one of the best-informed men I have ever met with, and extremely agreeable. Both he and Mr. Watt are still phlogitians; but Mr. Keir altogether disbelieves the doctrine of *calorique*.

What news have you in Cornwall? Has Mr. John Hawkins returned to his native county? he will doubtless be a great acquisition to you.

Pray do you know whether the Zoophyta and marine worms are susceptible of the galvanic stimulus? Experiments on them would go far to determine whether the irritable or sensitive fibre is primarily affected.

I know of little general scientific news. In the last volume of the *Annales de Chimie* is a curious paper by Berthollet on sulphurated hydrogen; he makes it out to be an acid; I shall most anxiously expect a letter from you, and I remain with affection and respect,

Yours,

HUMPHRY DAVY.

The letter which follows may be considered as a reply to one received from Mr. Davies Gilbert, which, it would appear, contained strictures upon his recently published Essays.

TO DAVIES GIDDY, ESQ.

MY DEAR FRIEND, April 10, 1799.

THE engagements resulting from the establishment of the Pneumatic Institution, and from a course of experiments, to which I have been obliged to pay great attention, have prevented me from acknowledging to you my obligations for the very great pleasure I received from your last excellent letter.

In experiments on Light and Heat, we have to deal with agents whose changes we are unable directly to estimate. The most we can hope for is such an arrangement of facts as will account for most of the phenomena.

The supposition of active powers common to all matter, from the different modifications of which all the phenomena of its changes result, appear to me more reasonable than the assumption of certain imaginary fluids alone endowed with active powers, and bearing the same relation to common matter, as the vulgar philosophy supposes spirit to bear to matter.

That the particles of bodies must move, or separate from each other, when they become expanded, is certain. A repulsive motion of the particles is directly the cause of expansion; and when bodies are expanded by friction, under circumstances in which there could be no heat communicated by bodies in contact, no oxidation and no diminution of capacity, I see no difficulty in conceiving the repulsive motion generated by the mechanical motion.

Your excellent and truly philosophic observations will induce me to pay greater attention to all my positions. It is only by forming theories, and then comparing them with facts, that we can hope to discover the true system of nature. I will endeavour very soon to give an answer to the remaining part of your excellent letter.

I have now just room to give you an account of the experiments I have lately been engaged in, though they are not much connected with light and heat.

First.—One of Mr. William Coate's children accidentally discovered that two bonnet-canes rubbed together produced a faint light. The novelty of this phenomenon induced me to examine it, and I found that the canes on collision produced sparks of light, as brilliant as those from the flint and steel.

Secondly. On examining the epidermis, I found, when it was taken off, that the canes no longer gave light on collision.

Thirdly. The epidermis, subjected to chemical analysis, had all the properties of silex.

Fourthly. The similar appearance of the epidermis of reeds, corn, and grasses, induced me to suppose that they likewise contained silex. By burning them carefully, and analysing their ashes, I found that they contained it in rather larger proportions than the canes.

Fifthly. The corn and grasses contain sufficient potash to form glass with their flint. A very pretty experiment may be made on these plants with the blow-pipe. If you take a straw of wheat, barley, or hay,* and burn it, beginning at the top, and heating the ashes with the blue flame, you will obtain a perfect globule of hard glass fit for microscopic experiments.

I made a discovery yesterday which proves how necessary it is to repeat experiments. The gaseous oxide of azote is perfectly respirable when pure. It is never deleterious but when it contains nitrous gas. I have found a mode of obtaining it pure, and I breathed to-day, in the presence of Dr. Beddoes

* It is very common, after the burning of a hay-stack, to find glass in the ashes. P.

and some others, sixteen quarts of it for near seven minutes. It appears to support life longer than even oxygen gas, and absolutely intoxicated me. Pure oxygen gas produced no alteration in my pulse, nor any other material effect; whereas this gas raised my pulse upwards of twenty strokes, made me dance about the laboratory as a madman, and has kept my spirits in a glow ever since. Is not this a proof of the truth of my theory of respiration? for this gas contains more light in proportion to its oxygen than any other, and I hope will prove a most valuable medicine.

We have upwards of eighty out-patients in the Pneumatic Institution, and are going on wonderfully well.

I shall hope for the favour of a letter from you, and in my answer to it will fully inform you of our proceedings. I have just room to add that I am

Yours, with affection and respect,

HUMPHRY DAVY.

I cannot suffer the experiments with the bonnet-canes to pass, without endeavouring to infuse into the reader a portion of that admiration which I feel in relating them. They furnish a beautiful illustration of that combination of observation, experiment, and analogy, first recommended by Lord Bacon, and so strictly adopted by Davy in all his future grand researches.

In alluding to this discovery—that siliceous earth exists generally in the epidermis of hollow plants—Davy observes in his agricultural lectures, that " the siliceous epidermis serves as a support, protects the bark from the action of insects, and seems to perform a part in the economy of these feeble vegetable tribes, similar to that performed in the animal kingdom by the shell of the crustaceous insects."

The circumstance that first led him to the investigation of the nature of *nitrous oxide*, or the *gaseous oxide of azote*, alluded to in the foregoing letter, has been thus recorded by himself. " A short time after I began the study of Chemistry, in March 1798, my attention was directed to the *dephlogisticated nitrous gas* of Priestley (nitrous oxide) by Dr. Mitchell's theory of Contagion, by which he attempted to prove that *dephlogisticated nitrous gas!* which he calls *oxide of septon*, was the principle of contagion, and capable of producing the most terrible effects, when respired by animals in the minutest quantities, or even when applied to the skin, or muscular fibre.

" The fallacy of this theory was soon demonstrated by a few coarse experiments, made on small quantities of this gas procured, in the first instance, from zinc and diluted nitrous acid. Wounds were exposed to its action; the bodies of animals were immersed in it without injury; and I breathed it, mingled in small quantities with common air, without any remarkable effects. An inability to procure it in sufficient quantities prevented me, at this time, from pursuing the experiments to any greater extent. I communicated an account of them to Dr. Beddoes."

His situation in the "Medical Pneumatic Institution" in 1799, imposing upon him the duty of investigating the physiological effects of such aëriform fluids as held out any promise of useful agency, he resumed the investigation; a considerable period, however, elapsed, before he succeeded in procuring *nitrous oxide* in a state of purity; he was therefore obliged to breathe it in mixture with oxygen gas, or common air; but as no just conclusion could be deduced from the action of an impure gas, he commenced an enquiry for the purpose of discovering a process by which it might be procured in an uncontaminated condition; when, after a most laborious investigation concerning its composition, properties, and combinations, enquiries which were necessarily extended to the different bodies connected with nitrous oxide, such as *nitrous gas*, *nitrous acid*, and *ammonia*, he was enabled, by a series of intermediate and comparative experiments, to reconcile apparent anomalies, and thus, by removing the greater number of those difficulties which had previously obscured this branch of science, to present to the chemical world the first satisfactory history of the COMBINATIONS OF OXYGEN AND NITROGEN.

Thus prepared, he proceeded to examine the action of nitrous oxide upon living beings, and to compare it with the effects of other gases upon man; and in this manner he completed its physiological, as he had already done its chemical history.

These interesting results were published in a distinct volume, in the year 1800, entitled, "Researches Chemical and Philosophical, chiefly concerning Nitrous Oxide, and its Respiration. By Humphry Davy, Superintendent of the Medical Institution."

It may be observed in passing, that the merits of this work could never have been inferred from the title-page, which its most sanguine admirers must admit to be as clumsy and unpromising an invitation as an author ever addressed to his scientific brethren.

Amongst Davy's letters to Mr. Gilbert, I find one written on a proof sheet of the chapter of contents of the above work, and which may not be uninteresting in this place.

TO DAVIES GIDDY, ESQ.

July 3, 1800.

That our feelings, as well as our actions, are rendered stronger and more vivid by habit, is probable from many facts, and from no one more so than that of procrastination. My much respected friend, two months after my return,* I had formed the resolution of writing to you; week after week this resolution was renewed and put off to a future day, with the hope that this day, by presenting something new, would enable me to make my letter more interesting. In vain! the feeling of procrastination, thus increased by association, at length became so strong as to prevent me from writing at all.†

I have received your letter; it has awakened my duties, and has been doubly welcome, as being unexpected and undeserved.

Since my return to the Pneumatic Institution in December, I have been almost incessantly occupied, from January to April, in completing a series of experiments on Gases, and their application; and from April to the present time, in writing and printing an account of them.

I have written this letter on the table of contents of a work which will be published in the course of the month, and of which I shall take the earliest opportunity to send you a copy. This table of contents will give you a better idea of the nature and extent of the investigation, than I could possibly have given in a letter.

We have been repeating the Galvanic experiments with success. Nicholson, by means of a hundred pieces of silver and zinc, has procured a visible spark. Cruickshank has revived oxidated metals in solution, by means of the nascent hydrogen produced from the decomposition of water by the shock; and both he and Carlisle have absolutely resolved water into oxygen and hydrogen by means of it, making use of silver and platina wires. An immense field of investigation seems opened by this discovery: may it be pursued so as to acquaint us with some of the laws of life!

* From his visit to London, as noticed at page 43.

† With respect to the metaphysical speculation contained in this paragraph of his letter, had he not written it in haste, we might presume he would have given a more exact expression to his ideas. By the misapplied term "*Feeling of Procrastination*," he doubtless meant to describe that aversion to labour which becomes habit by indulgence, and the perception of which, so far from increasing in vividness, actually languishes to obtuseness. To borrow an expression from Dr. Johnson, Davy, in his metaphysical speculations, not unfrequently trod upon the brink of meaning, where light and darkness begin to mingle.

You have, undoubtedly, heard of Herschel's discovery concerning the production of heat by invisible rays emitted from the sun. By placing one thermometer within the red rays, separated by a prism, and another beyond them, he found the temperature of the outside thermometer raised more than that of the inside one.

When I first heard of Mr. Tennant's discovery,* I was very much struck by an observation which you long ago made to me, on the fertility of the Cornish lands, in which there was decomposed, *feltspar* or *serpentine*.

Mr. Tennant spent a day here some time ago, when I mentioned your observation to him, but he could not give any solution of the phenomenon. *Quere.*—As lime and magnesia are probably both subservient to vegetation, only from supplying plants with carbonic acid, may not lime, when mingled with magnesia, in the process of vegetation, render it partially caustic, and thus enable it to destroy them?

Your observation on the scale of numbers, and the fact relative to it, are highly interesting. Reasoning on this subject would literally form the logic of generalization, or the application of one term to signify many terms, or many ideas, on which science ultimately depends. *Quere.*—How far have the first attempts at generalization arisen from accident, and how far from the resemblance between ideas?

Dr. Beddoes has always ridiculed the " *Tractors*," in common with all other reasonable men. He is about to publish a new work on the Nitrous Acid.

J. Wedgwood is returned, very little altered for the better. Coleridge is gone to reside in Cumberland; he was here the week before last, and spent much time with me, and often spoke of you with the greatest interest. Clayfield is at this moment chiefly engaged in commercial speculations. He has found a new mode of making soda, which there is every reason to believe will turn out profitable.

I hope some time in the autumn to see you, and to enjoy the well remembered pleasure of your conversation; in the mean while, I remain, with respects to your family,

Yours with sincere affection,

HUMPHRY DAVY.

* Davy here alludes to the fact of magnesian earth being prejudicial to vegetation.

In estimating the early genius of Davy, and his character as a philosopher, the style and matter of his "RESEARCHES" will afford us much assistance. The close philosophical reasoning,—the patient and penetrating industry,—the candid submission to every intimation of experiment, and the accuracy of manipulation, so remarkably displayed throughout this work, have been rarely equalled, and perhaps never surpassed.

There is scarcely to be found a more striking illustration of chemical genius, than that afforded by his chapter on the "Absorption of *Nitrous Gas, by solutions of green Sulphate of Iron.*"

The address with which he gradually disentangles the subject of its difficulties, and catches at every opening to truth, affords a study which may be safely recommended to the attention of every young experimentalist, as being no less instructive than it is beautiful.

The phenomena attending the absorption of *nitrous gas* by solutions of *sulphate of iron* had been examined by Vauquelin and by Berthollet, but the conclusions of these chemical philosophers were fatally infected by errors, arising from the neglected action of the atmosphere. Davy, by conducting his experiments over mercury, proved that, in the absence of air, the absorption was simply owing to a combination between the gas and the fluid, but that, on admitting air, the nitrous *gas* became nitrous *acid*, a portion of which, together with a part of the water, subsequently underwent decomposition, and gave origin to *ammonia*, and ultimately to *nitrate of ammonia*, while the iron passed into the state of a *peroxide.*

We have also to admire in this work an ardour for investigation, which even the most imminent personal danger could not repress. He may truly be said to have sought the bubble reputation in the very jaws of Death. What shall we say of that spirit which led him to inspire nitrous gas, at the hazard of filling his lungs with the vapour of *aqua fortis!* or what, of that intrepid coolness which enabled him to breathe a deadly gas, and to watch the advances of its chilling power in the ebbing pulsations at the wrist!

These experiments, however, are far too interesting and important to be related in any other than the author's own words; but it is first necessary that his trials with the *nitrous oxide* should be considered.

He found that this gas might be most conveniently, as well as most economically, prepared by the decomposition of a salt known by the name of *nitrate of ammonia*, by the application of a regulated heat; but, as the researches by which he arrived at this conclusion are recorded at length in his work, and as the most important of them are now embodied in every elementary system of chemistry, it would not only be tedious but useless, to enter into a detail of them upon this occasion.

"In April," he says, "I obtained nitrous oxide in a state of purity, and ascertained many of its chemical properties. Reflections upon these properties, and upon former trials, made me resolve to inspire it in its pure form, for I saw no other way in which its respirability, or powers, could be determined.

"I was aware of the danger of the experiment. It certainly would never have been made, if the hypothesis of Dr. Mitchell had in the least influenced my mind. I thought that the effects might, possibly, be depressing and painful, but there were many reasons which induced me to believe, that a single inspiration of a gas, apparently possessing no immediate action on the irritable fibre, could neither destroy, nor materially injure the powers of life.

"On April 11th, I made the first inspiration of pure nitrous oxide. It passed through the bronchiæ without stimulating the glottis, and produced no uneasy sensations in the lungs.

"The result of this experiment proved that the gas was respirable, and induced me to believe that a farther trial of its effects might be made without danger.

"On April 16th, Dr. Kinglake being accidentally present, I breathed three quarts of nitrous oxide from and into a silk bag, for more than half a minute, without previously closing my nose, or exhausting my lungs. The first inspirations occasioned a slight degree of giddiness, which was succeeded by an uncommon sense of fulness in the head, accompanied with loss of distinct sensation and voluntary power,—a feeling analogous to that produced in the first stage of intoxication; but unattended by pleasurable sensation. Dr. Kinglake, who felt my pulse, informed me that it was rendered quicker and fuller.

"This trial did not satisfy me with regard to its powers; comparing it with the former ones, I was unable to determine whether the operation was stimulant or depressing.

"I communicated the result to Dr. Beddoes, and on April the 17th, he was present when the following experiment was made.

"Having previously closed my nostrils, and exhausted my lungs, I breathed four quarts of the gas, from and into a silk bag. The first feelings were similar to those produced in the last experiment; but in less than half a minute, the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by an highly pleasurable thrilling, particularly in the chest and in the extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspirations, the thrilling increased, the sense of muscular power became greater, and, at last, an irresistible propensity to action was indulged in; I recollect but indistinctly what followed; I know that my motions were various and violent.

"These effects very soon ceased after the respiration of the gas. In ten minutes I had recovered my natural state of mind. The thrilling in the extremities continued longer than the other sensations.

"This experiment was made in the morning; no languor or exhaustion was consequent; my feelings throughout the day were as usual, and I passed the night in undisturbed repose.

"The next morning the recollection of the effects of the gas was very indistinct; and had not remarks written immediately after the experiment recalled them to my mind, I should even have questioned their reality."

Our philosopher very naturally doubted whether some of these strong emotions might not, after all, be attributed to the enthusiasm necessarily connected with the perception of agreeable feelings, when he was prepared to expect painful sensations; but he says, that subsequent experiments convinced him that the effects were solely owing to the specific operation of the gas. He found that he could breathe nine quarts of nitrous oxide for three minutes, and twelve quarts for rather more than four; but that he could never breathe it, in any quantity, so long as five minutes. Whenever its operation was carried to the highest extent, the pleasurable thrilling, at its height about the middle of the experiment, gradually diminished, the sense of pressure on the muscles was lost, impressions ceased to be perceived, vivid ideas passed rapidly through the mind, and voluntary power was altogether destroyed, so that the mouth-piece generally dropped from his unclosed lips. When he breathed from six to seven quarts, muscular motions were produced to a great extent; sometimes he manifested his pleasure by stamping, or laughing only; at other times, by dancing round the room, and vociferating.

During the progress of these experiments, it occurred to him that, supposing *nitrous oxide* to be analogous in its operation to common stimulants, the debility occasioned by intoxication from fermented liquors ought to be increased after excitement from this gas, in the same manner as the debility produced by two bottles of wine is increased by a third. To ascertain whether this was the case, he drank a bottle of wine, in large draughts, in less than eight minutes. His usual drink, he tells us, was water; he had been little accustomed to take spirits, or wine, and had never been intoxicated, but once before, in the course of his life. Under such circumstances, we may readily account for the powerful effects produced by this quantity of wine, and which he describes in the following manner:—

"Whilst I was drinking, I perceived a sense of fulness in the head, and throbbing of the arteries, not unlike that produced in the first stage of nitrous oxide excitement: after I had finished the bottle, this fulness increased, the objects around me became dazzling, the power of distinct articulation was lost, and I was unable to stand steadily. At this moment, the sensations were rather pleasurable than otherwise; the sense of fulness in the head, however, soon increased, so as to become painful, and in less than an hour I sunk into a state of insensibility. In this situation I must have remained for two hours, or two hours and a half. I was awakened by head-ache and painful nausea. My bodily and mental debility were excessive, and the pulse feeble and quick.

"In this state, I breathed for near a minute and a half five quarts of gas, which was brought to me by the operator for nitrous oxide; but as it produced no sensations whatever, and apparently rather increased my debility, I am almost convinced that it was, from some accident, either common air, or very impure nitrous oxide.

"Immediately after this trial, I respired twelve quarts of oxygen for nearly four minutes. It produced no alteration in my sensations at the time, but immediately afterwards I imagined that I was a little exhilarated.

"The head-ache and debility still, however, continuing with violence, I examined some nitrous oxide which had been prepared in the morning, and finding it very pure, I respired seven quarts of it for two minutes and a half. I was unconscious of head-ache after the third inspiration; the usual pleasurable thrilling was produced, voluntary power was destroyed, and vivid ideas rapidly passed through my mind; I made strides across the room, and continued for some minutes much exhilarated; but languor and depression, not very different in degree from those existing before the experiment, succeeded; they however gradually went off before bed-time.

"This experiment proved, that debility from intoxication was not increased by excitement from nitrous oxide. The head-ache and depression would probably have continued longer, had it not been administered."

The same work contains an account of many other trials; but sufficient has been extracted to show the zeal and intrepidity with which he conducted his researches. To withhold, however, the testimony which several other scientific persons have given, with respect to the intoxicating influence of this gas, would be to deprive the reader of some very amusing descriptions.

First appears Mr. W. Tobin, who tells us that he soon found his nervous system agitated by the highest sensations of pleasure, but which were difficult of description. When the bags were exhausted and taken from him, he suddenly started from his chair, and vociferating with pleasure, made towards those that were present, as he wished they should participate in his feelings. He struck gently at Davy, and a stranger entering the room at the same moment, he made towards him, and gave him several blows, but he adds, it was more in the spirit of good-humour, than in that of anger. He then ran through different rooms in the house, and at last returned to the laboratory, somewhat more composed, although his spirits continued much elevated for some hours after the experiment; he felt, however, no consequent depression, either in the evening or day following. Upon another occasion, he states that his sensations were superior to any thing he ever before experienced; his step was firm, and all his muscular power increased. His nerves were more alive to every surrounding impression; he threw himself into several theatrical attitudes, and traversed the laboratory with a quick step, while his mind was elevated to a most sublime height: he says that "it is giving but a faint idea of his feelings to say, that they resembled those produced by a representation of an heroic scene on the stage, or by reading a sublime passage in poetry, when circumstances contribute to awaken the finest sympathies of the soul." The influence, however, of this inspiring agent appears to have been as transitory as its effects were vivid; for he afterwards observes, "I have seldom lately experienced vivid sensations. The pleasure produced by the gas is slight and tranquil, and I rarely feel sublime emotions, or increased muscular power."

The first time that Mr. Clayfield breathed the gas, it produced feelings analogous to those of intoxication. He was for some time unconscious of existence, but at no period of the experiment were his sensations agreeable; a momentary nausea followed, but unconnected with languor or head-ache.

In a subsequent trial, it would appear that he did experience certain thrillings which were highly pleasurable.

The account given by Dr. Kinglake agrees pretty much with those already cited. He adds, however, that the inspiration of the gas had the further effect of reviving rheumatic irritations in the shoulder and knee-joints, which had not been previously felt for many months.

Next appears Mr. Southey, the Laureate. The reader will no doubt be prepared to hear that the nitrous oxide transported him, at least, to the summit of Parnassus;—by no means; he laughed when the bag was removed from his mouth, but it may be fairly questioned whether this might not have been an expression of joy at the terrors he had escaped; for he freely confesses that he could not distinguish between the first feelings it occasioned, and an apprehension of which he was unable to divest himself.

The first time Mr. Coleridge inspired the nitrous oxide he felt a highly pleasurable sensation of warmth over his whole frame; he adds that the only motion which he felt inclined to make was that of laughing at those who were looking at him; a symptom as equivocal, perhaps, as that exhibited by the Laureate.

A number of other accounts are given, but those already related are perhaps sufficient to establish the fact, that the gas in question possesses an intoxicating quality, to which the enthusiasm of persons submitting to its operation has imparted a character of extravagance wholly inconsistent with truth.

It will be admitted that there must have been something singularly ludicrous in the whole exhibition. Imagine a party of grave philosophers, with bags of silk tied to their mouths, stamping, roaring, and laughing about the apartment; it is scarcely possible to conceive a richer subject for the pencil of a Bunbury. We cannot then be surprised at any terms of ridicule in which a stranger, witnessing such an operation, might describe it. M. T. Fievée* appears to have considered the practice as a national vice, and whimsically introduces it amongst the catalogue of follies to which he considers the English nation to be addicted.

Taking leave of these laughing philosophers, we must now proceed to a much more serious branch of the subject of Pneumatic Medicine. "Having observed," says Davy, "that no painful effects were produced by the applica-

* Lettres sur l'Angleterre, 1802.

tion of nitrous gas to the bare muscular fibre, I began to imagine that this gas might also be breathed with impunity, provided it were possible in any way to free the lungs of common air before inspiration, so as to prevent the formation of nitrous acid.

"On this supposition, during a fit of enthusiasm produced by the respiration of nitrous oxide, I resolved to endeavour to breathe nitrous gas; one hundred and fourteen cubic inches of it were accordingly introduced into the large mercurial air-holder; two small silk bags of the capacity of seven quarts were filled with nitrous oxide.

"After a forced exhaustion of my lungs, my nose being accurately closed, I made three inspirations and expirations of nitrous oxide in one of the bags, in order to free my lungs, as much as possible, from atmospheric oxygen; then, after a full expiration of the nitrous oxide, I transferred my lips from the mouthpiece of the bag to that of the air-holder, and turning the stopcock attempted to inspire the nitrous gas. In passing through my mouth and fauces, it tasted astringent and highly disagreeable; it occasioned a sense of burning in the throat, and produced a spasm of the epiglottis, so painful as to oblige me to desist immediately from attempts to inspire it. After removing my lips from the mouthpiece, when I opened them to inspire common air, *nitrous acid* was immediately formed in my mouth, which burnt the tongue and palate, injured the teeth, and produced an inflammation of the mucous membrane, which lasted for some hours.

"As, after the respiration of nitrous oxide, a small portion of the residual atmospheric air always remained in the lungs mingled with the gas, so is it probable that, in the experiment just related, a minute portion of nitrous acid was formed; and, if so, I perhaps owe the preservation of my life to the circumstance: for, supposing that I had succeeded in taking a full inspiration of nitrous gas, and even that it had not produced any positive effects, it is not likely that I should, by breathing nitrous oxide, have so completely freed my lungs from it, as to have prevented the formation of nitrous acid, when I again inspired common air. I never design again to attempt so rash an experiment."

His attempt to breathe carburetted hydrogen gas was scarcely less terrific and appalling.

"Mr. Watt's observations on the respiration of diluted *hydro-carbonate* by man, and the experiments of Dr. Beddoes on the destruction of animals by the same gas, proved that its effects were highly deleterious.

"As it destroyed life, apparently by rendering the muscular fibre inirritable, without producing any previous excitement, I was anxious to compare its sensible effects with those of nitrous oxide, which at this time I believed to destroy life by producing the highest possible excitement.

"In the first experiment, I breathed for nearly a minute three quarts of *hydro-carbonate*, mingled with nearly two quarts of atmospheric air.* It produced a slight giddiness, pain in the head, and a momentary loss of voluntary power; my pulse was rendered much quicker and more feeble. These effects, however, went off in five minutes, and I had no return of giddiness.

"Emboldened by this trial, I introduced into a silk bag four quarts of gas nearly pure, which was carefully produced from the decomposition of water by charcoal an hour before, and which had a very strong and disagreeable smell.

"My friend Mr. James Tobin, junior, being present, after a forced exhaustion of my lungs, the nose being accurately closed, I made three inspirations and expirations of the hydro-carbonate. The first inspiration produced a sort of numbness and loss of feeling in the chest, and about the pectoral muscles. After the second, I lost all power of perceiving external things, and had no distinct sensation, except that of a terrible oppression on the chest. During the third expiration, this feeling subsided, I seemed sinking into annihilation, and had just power enough to cast off the mouthpiece from my unclosed lips.

"A short interval must have passed, during which I respired common air, before the objects around me were distinguishable. On recollecting myself, I faintly articulated, '*I do not think I shall die.*' Placing my finger on the wrist, I found my pulse thread-like, and beating with excessive quickness. In less than a minute, I was able to walk, and the painful oppression on the chest directed me to the open air.

"After making a few steps, which carried me to the garden, my head became giddy, my knees trembled, and I had just sufficient voluntary power to throw myself on the grass. Here the painful feelings of the chest increased with such violence as to threaten suffocation. At this moment I asked for some nitrous oxide, Mr. Dwyer brought me a mixture of

* "I believe it had never been breathed before by any individual in a state so little diluted."

that gas with oxygen, and I breathed it for a minute, and believed myself recovered.

"In five minutes the painful feelings began gradually to diminish; in an hour they had nearly disappeared, and I felt only excessive weakness, and a slight swimming of the head. My voice was very feeble and indistinct.

"I afterwards walked slowly for half an hour with Mr. Tobin, and on my return was so much stronger and better as to believe that the effects of the gas had entirely passed off; though my pulse was 120, and very feeble. I continued without pain for nearly three quarters of an hour, when the giddiness returned with such violence as to oblige me to lie on the bed; it was accompanied with nausea, loss of memory, and deficient sensation.

"In about an hour and a half, the giddiness went off, and was succeeded by an excruciating pain in the forehead, and between the eyes, with transient pains in the chest and extremities.

"Towards night these affections gradually diminished; and at ten no disagreeable feeling, except weakness, remained. I slept sound, and awoke in the morning very feeble, and very hungry. No recurrence of the symptoms took place, and I had nearly recovered my strength by the evening.

"I have been minute in the account of this experiment, because it proves, that *hydro-carbonate* acts as a sedative, that is, it produces diminution of vital action, and consequent debility, without previously exciting. There is every reason to believe that, had I taken four or five inspirations, instead of three, they would have destroyed life immediately, without producing any painful sensation."

The scientific and medical world are alike indebted to Davy for this daring experiment; and, if the precautions it suggests be properly attended to, it may become the means of preserving human life. The experiment is also valuable as affording support to physiological views, with which its author was probably not acquainted.

In the first place, it may be necessary to apprize some of my readers, that the "*hydro-carbonate*" here spoken of, differs very little from the gas now so generally used to illuminate our streets and houses. We have just seen how deadly are its qualities, and that even in a state of extreme dilution it will affect our sensations. The question then necessarily suggests itself, how far this gas can be safely introduced into the interior of our apartments? Did we not possess any direct evidence upon the subject, the answer would be sufficiently obvious, since it is impossible so to conduct its combustion, that a portion shall not escape unburnt. Such is the theory; but what is our experience upon the subject?—that pains in the head, nausea, and distressing languor, have been repeatedly experienced in our theatres and saloons, by persons inhaling the unburnt gas; that the atmosphere of a room, although spacious and empty, will, if lighted with gas, convey a sense of oppression to our organs of respiration, as if we were inhaling an air contaminated with the breath of a hundred persons.

In the next place, Davy's experiment is important, inasmuch as it proves that, in cases of asphyxia, or suspended animation, there exists a period of danger after the respiration has been restored, and the circulation re-established, at which death may take place, when we are the least prepared to expect it.

Bichat has shewn that, when dark-coloured blood is injected into the vessels of the brain by means of a syringe connected with the carotid artery, the functions of the brain become immediately disturbed, and in a short time entirely cease; the effect is precisely similar, whether the dark-coloured blood be transmitted to the brain by the syringe of the experimentalist, or by the heart itself. Thus in cases of asphyxia, the dark-coloured blood which has been propelled through the vessels during the suspension or imperfect performance of respiration, acts like a narcotic poison upon the brain; and no sooner, therefore, does it extend its malign influence to that organ, than deleterious effects are produced, and the animal, after apparent recovery, falls into a state of stupor, the pupils of the eyes become dilated, the respiration laborious, the muscles of the body convulsed, and it speedily dies, *poisoned by its own blood.*

We are much indebted to Mr. Brodie for a series of experiments in confirmation of these views; and a very interesting case occurred some time since, in the neighbourhood of Windsor, which is well calculated for their illustration. A corporal in the guards, whose name, if I am not mistaken, was Schofield, was seized with cramp as he was bathing in the Thames, and remained for several minutes under water. By judicious assistance, however, he was recovered, and appeared to those about him to be free from any danger, when he was attacked by convulsions and expired. Had the respiration been artificially supported at this period, so as to have maintained the action of the heart until the black blood had returned from the brain, the life of the soldier might possibly have been saved.

In the experiment which has given origin to these reflections, Davy distinctly states, that after having recovered from the *primary* effects of the carburetted hydrogen gas, and taken a walk with his friend Mr. Tobin, he was again seized with violent giddiness, attended with nausea, and loss of sensation. The imperfectly oxygenized or dark-coloured blood had evidently affected the brain, and his life, at this period, was probably in greater jeopardy than in any other stage of the experiment.

Nothing daunted by the dangers to which the preceding experiments had exposed him, Davy did not allow more than a week to elapse before he attempted to respire *fixed air*, or *carbonic acid gas;* but it was in vain that he made voluntary efforts to draw it into the windpipe, for the moment the epiglottis was raised a little, such a painful irritation was induced as instantly to close it spasmodically on the glottis; and thus, in repeated trials, was he prevented from taking a single particle of carbonic acid into the lungs. When, however, the gas was diluted with a little more than double its volume of common air, he was enabled to breathe it for nearly a minute, when it produced a slight degree of giddiness, and an inclination to sleep.*

It may perhaps appear extraordinary to the reader of the "RESEARCHES," that although they were published not more than eighteen months after the appearance of his "Essays on Heat and Light," no allusion is made in them either to his theory or to his new nomenclature. In relating his experiments upon Respiration, he employs the conventional language of the schools, and the word "*phos-oxygen*" does not once occur in the volume. This is fully explained in a communication made by him to Mr. Nicholson, and which was printed in his Journal a short time after the publication of his Essays in the West Country Contributions; in which he says,— "As facts have occurred to me with regard to the decomposition of bodies, which I had supposed to contain light, without any luminous appearance, I beg to be considered as a *sceptic* with respect *to my own* particular theory of the combinations of light,

* It would thus appear that carbonic acid, in its most concentrated form, may kill by exciting a spasmodic action, in which the epiglottis is closed, and the entrance of air into the lungs altogether prevented. In a diluted form, it may destroy by its specific influence upon the blood, which would seem to be of a highly-sedative character. Death produced by such an agent is probably attended with little or no suffering. The younger Berthollet destroyed his life by inclosing himself in an atmosphere of this description; and on commencing his fatal experiment, he registered all the successive feelings he experienced, which were such as would have been occasioned by a narcotic:—a pause, and then an almost illegible word occurred: it is presumed that the pen dropped from his hand,—and he was no more.

until I shall have satisfactorily explained those anomalies by fresh experiments. On account of this scepticism, and for other reasons, I shall in future use the common nomenclature; excepting that, as my discoveries concerning the gaseous oxide would render it highly improper to call a principle, which in one of its combinations is capable of being absorbed by venous blood, and of increasing the powers of life, *azote*,—I shall name it, with Dr. Pearson, Chaptal, and others, NITROGENE; and the *gaseous oxide of azote* I shall call NITROUS OXIDE."

The same feeling is expressed at the conclusion of his Third Research.—"It would be easy to form theories referring the action of blood impregnated with *nitrous oxide*, to its power of supplying the nervous and muscular fibre with such proportions of condensed nitrogen, oxygen, light, or ethereal fluid, as enabled them more rapidly to pass through those changes which constitute their life; but we are unacquainted with the composition of dead organized matter; and new instruments of experiment, and new modes of research, must be found, before we can ascertain even our capabilities of discovering the laws of life."

There is one circumstance connected with the views entertained in this work which must not be passed over without notice. In several passages he advocates the theory of the atmosphere being a *chemical compound* of oxygen and nitrogen; whereas, in later years, he was amongst the first to insist upon its being simply a mechanical mixture of these gases.

In consequence of the highly deleterious experiments which have been already described, and of the constant labours of the laboratory, and the repeated inhalation of acid and other vapours, his health began visibly to decline, and he retired into Cornwall, where he informs us that "the associations of ideas and feelings, common exercise, a pure atmosphere, luxurious diet, and a moderate indulgence in wine, in the course of a month restored him to health and vigour."

I find an allusion to this visit in a letter from his sister. "He had," she says, "written to his mother of his intention to visit her, but before the post had quitted Bristol, he was already on his way to Penzance, and would have reached it before his letter, had not his aunt, on whom he called in the neighbouring town of Marazion, struck with his appearance of ill health, insisted on his remaining there till the next day, lest his mother should be doubly alarmed at his unexpected visit, and altered looks." Miss Davy adds, "This one fact will serve, at the same time, to illustrate his attachment to home, and the impetuosity of his mind, which never rested till the object he proposed was accomplished."

The following letter is inserted in this place, for the purpose of fixing the period at which he first ascertained those new facts in Voltaic electricity, which formed the basis of a future communication to the Royal Society, and which may be said to have paved the way to his grand discoveries in that branch of science;—the dawning of that glorious day, which we shall presently view in all its splendour and glory.

There is, moreover, something extremely interesting in receiving from himself a simple and unadorned statement of results, as they successively presented themselves to his observation—"Truths plucked as they are growing, and delivered to you before their dew is brushed off."

TO DAVIES GIDDY, ESQ.

Pneumatic Institution, October 20, 1800.

Be assured, my respected friend, that your last letter, though short, was highly gratifying to me. At the moment it was brought to me, I was about to depart with King and Danvers on an excursion to the banks of the Wye. Our design was to see Tintern Abbey by moonlight, and it was perfectly accomplished.

After viewing for three hours all the varieties of light and shade, which a bright full moon and a blue sky could exhibit in this beautiful ruin; and after wandering for three days among the many-coloured woods and rocks surrounding the river, between Monmouth and Chepstow, we arrived on the fourth day at Bristol, having to balance against the pleasure of the tour, the fatigue of a stormy voyage down the Wye, across the mouth of the Severn, and up the Avon.

On analysing, after our return, specimens of the air collected from Monmouth, from the woods on the banks of the Wye, and from the mouth of the Severn, there was no perceptible difference; they were all of similar composition to the air in the middle of Bristol, that is, they contained about twenty-two per cent. of oxygen. The air from the bladders of some sea-weed, apparently just cast on shore, at the Old Passage, likewise gave the same results so that, comparing these experiments with those made by Cavendish, Berthollet, &c. and by myself on other occasions, at different temperatures, in different weather, and with different winds, I am almost convinced that the whole of the lower stratum of the atmosphere is of uniform composition.

No test can be more fallacious and imperfect than nitrous gas, on account of the different composition of nitrous acid, formed in the different manipulations of eudiometrical experiments.

The eudiometer that I have lately employed gives, in a few minutes, the proportions of oxygen without correction.

In pursuing experiments on galvanism, during the last two months, I have met with unexpected and unhoped-for success. Some of the new facts on this subject promise to afford instruments capable of destroying the mysterious veil which Nature has thrown over the operations and properties of ethereal fluids.

Galvanism I have found, by numerous experiments, to be *a process purely chemical*, and to depend wholly on the oxidation of metallic surfaces, having different degrees of electric conducting power.

Zinc is incapable of decomposing *pure* water; and if the zinc plates be kept moist with *pure* water, the galvanic pile does not act; but zinc is capable of oxidating itself when placed in contact with water, holding in solution either oxygen, atmospheric air, or nitrous or muriatic acid, &c.: and under such circumstances, the galvanic phenomena are produced, and their intensity is in proportion to the rapidity with which the zinc is oxidated.

The galvanic pile only acts for a few minutes, when introduced into hydrogen, nitrogen, or hydro-carbonate; that is, only as long as the water between its plates holds some oxygen in solution; immerse it for a few moments in water containing air, and it acts again.

It acts very vividly in oxygen gas, and less so in the atmosphere. When its plates are moistened by marine acid, its action is very powerful, but infinitely more so when nitrous acid is employed. Five plates with nitrous acid gave sparks equal to those of the common pile. From twenty plates the shock was insupportable.

I had almost forgotten to mention, that charcoal is a good galvanic exciter, and decomposes water, like the metals, in the pile; but I must stop, without being able to expatiate on the connection which is now obvious between galvanism and some of the phenomena of organic motion. I never consider the subject without having forcibly impressed upon my imagination your observations * on the science of the ethereal fluids, and I cannot help flattering myself that this age will see your predictions verified. I remain with sincere respect and affection, Yours,

HUMPHRY DAVY.

That a work, of the character of the "RESEARCHES," replete with ingenious novelty, and rich in chemical discovery, proceeding from the pen of so young a man, should have excited very general admiration in the philosophic world, is a circumstance that cannot surprise us; but in a majority of cases, precocious merit enjoys only an ephemeral popularity; the sensations it excites are too vivid to be permanent, and the individual sinks into an obscurity rendered ten times more profound by the brilliancy of the flash which preceded it; but every event of Davy's life would appear as if created, and directed for his welfare, by some presiding genius, whose activity in throwing opportunities in his way was rivalled only by the address with which he converted them to his advantage. Fortune and talent, then, were both equally engaged in accomplishing the elevation of Davy, and it is probable that eminent success generally requires a combination of these elements for its production, and that the maxim of Plautus is therefore as remote from truth as that of Theophrastus, the one assigning all to fortune, the other all to talent.

The experiments to which allusions have been frequently made during the present chapter, favourably as they were received, might have shared the fate of many other discoveries which did not admit of an immediate and obvious application to the purposes of common life; for statistical value is a necessary passport to popular favour. Fortunately, however, for Davy, before the vivid impression produced by his new work had lost the glow of novelty, Count Rumford was anxiously seeking for some rising philosopher, who might contribute his energies towards the support, and farther increase, of the chemical fame of the recently established "INSTITUTION OF GREAT BRITAIN."

It is not surprising that his attention should have been readily directed to one whose genius had been so lately displayed, and whose views regarding Caloric † were in such exact conformity with his own opinions.

* On conversing with Mr. Gilbert on the above passage, I understand that it is an allusion to his opinion, that the discovery of Galvanic power would ultimately lead to a knowledge of the nature of light and heat.

† Mr. Gilbert no sooner discovered the tendency of Davy's opinions, respecting the immateriality of Caloric, than he urged him to communicate them to Count Rumford, but he considered himself

As the philosophical public must feel a lively interest in every incident connected with a transaction so important to the interests of science, as that by which Davy was placed in the chemical chair of the Institution, I am fortunate in being able, through the kindness of his two friends, Mr. Thomson and Mr. Underwood, to present a clear and satisfactory statement of all its circumstances and details.

pledged to Dr. Beddoes, and his Essays were accordingly printed in the West Country Contributions. Count Rumford, it may be observed, maintained that Caloric, like *Phlogiston*, was merely a creature of the chemist's imagination, and had no real existence. He considered heat as nothing more than the motions of the constituent particles of bodies amongst themselves,—an hypothesis which has no claims to novelty; being, perhaps, one of the most ancient on record.—See his paper on Heat, *Phil. Trans.* for 1804.

CHAPTER III.

Count Rumford negotiates with Mr. Underwood on the subject of Davy's appointment to the Royal Institution.—Terms of his engagement communicated in a letter to Mr. Gilbert.—Davy arrives, and takes possession of his apartments.—He receives various mortifications.—He is elected a member of the Tepidarian Society.—Is appointed Lecturer instead of assistant.—He makes a tour in Cornwall with Mr. Underwood.—Anecdotes.—His Poem on Spinosism.—His letter to Mr. Gilbert, communicating a galvanic discovery.—He commences his first grand course of lectures.—His brilliant success.—A letter from Mr. Purkis.—Davy's style criticised.—His extraordinary method of experimenting.—Davy and Wollaston compared as experimentalists.—The style of Davy as a lecturer and a writer contrasted.

It may be readily supposed that the prominent situation held by Davy at Bristol, as well as the merited celebrity of his writings, must have rendered his name familiar to all the leading philosophers of the day. It were vain, therefore, to enquire through what channel the echo of his fame first reached the ear of Count Rumford;* it is sufficient to state that Mr. Underwood, a gentleman ardently attached to science, and devoted to the interests of the Royal Institution, was amongst the first to urge the expediency of inviting him to London as a public lecturer. Mr. Underwood, in a letter lately addressed to me from Paris, says, "In consequence of several conversations with Count Rumford, on the subject of Davy's superior talents, and the advantages that would accrue to the Institution from engaging him as a lecturer, the Count

* Amongst other celebrated chemists who had become acquainted with Davy at Bristol, and subsequently spoken of his extraordinary genius, was Dr. Hope. He informs me that Count Rumford had applied to him to find some chemist who would undertake the office of lecturer at the Institution; but that he failed in discovering such a person as he could, with propriety, introduce; some time afterwards, however, he became acquainted with Davy, and having soon perceived his talents, recommended him without any hesitation to the patronage of the Count. This circumstance, combined with several others, no doubt might have had its influence in deciding the fate of Davy.

called upon me on the 5th of January 1801, having received from the managers of the Institution full powers to negotiate upon the subject. On this occasion, however, I thought it advisable to introduce the Count to Mr. James Thomson, as being the more eligible person to treat in behalf of Davy, not only on account of his greater intimacy with him, but because, not being a proprietor, he was unconnected with the interests of the Institution."

Mr. Thomson, who saw the prospect of honour and emolument thus opened for his friend, after a satisfactory interview with Count Rumford, immediately wrote to Davy, with an earnest recommendation that he should, without loss of time, come to town, and conclude an arrangement thus auspiciously commenced.

Davy, with his characteristic ardour, answered the letter in person. He was introduced to the managers, and the preliminary arrangements were soon completed; the nature of which is disclosed by Davy himself in the following letter to Mr. Gilbert.

Hotwells, March 8, 1801.

I cannot think of quitting the Pneumatic Institution, without giving you intimation of it in a letter; indeed, I believe I should have done this some time ago, had not the hurry of business, and the fever of emotion produced by the prospect of novel changes in futurity, destroyed to a certain extent my powers of consistent action.

You, my dear Sir, have behaved to me with great kindness, and the little ability I possess you have very much contributed to develope; I should therefore accuse myself of ingratitude, were I to neglect to ask your approbation of the measures I have adopted with regard to the change of my situation, and the enlargement of my views in life.

In consequence of an invitation from Count Rumford, given to me with some proposals relative to the Royal Institution, I visited London in the middle of February, where, after several conferences with that gentleman, I was invited by the Managers of the Royal Institution to become the Director of their laboratory, and their Assistant Professor of chemistry; at the same time I was assured that, within the space of two or three seasons, I should be made sole Professor of Chemistry, still continuing Director of the laboratory.

The immediate emolument offered was sufficient for my wants; and the sole and uncontrolled use of the apparatus of the Institution, for private experiments, was to be granted me.

The behaviour of Count Rumford, Sir Jospeh Banks, Mr. Cavendish, and the other principal managers, was liberal and polite; and they promised me any apparatus that I might need for new experiments.

The time required to be devoted to the services of the Institution was but short, being limited chiefly to the winter and spring. The emoluments to be attached to the office of sole Professor of Chemistry are great; and, above all, the situation is permanent, and held very honourable.

These motives, joined to the approbation of Dr. Beddoes, who with great liberality has absolved me from my engagements at the Pneumatic Institution, and the strong wishes of most of my friends in London and Bristol, determined my conduct.

Thus I am quickly to be transferred to London, whilst my sphere of action is considerably enlarged, and as much power as I could reasonably expect, or even wish for at my time of life, secured to me without the obligation of labouring at a profession.

The Royal Institution will, I hope, be of some utility to society. It has undoubtedly the capability of becoming a great instrument of moral and intellectual improvement. Its funds are very great. It has attached to it the feelings of a great number of people of fashion and property, and consequently may be the means of employing, to useful purposes, money which would otherwise be squandered in luxury, and in the production of unnecessary labour.

Count Rumford professes that it will be kept distinct from party politics; I sincerely wish that such may be the case, though I fear it.* As for myself, I shall become attached to it full of hope, with the resolution of employing all my feeble powers towards promoting its true interests.

So much of my paper has been given to pure egotism, that I have but little room left to say any thing concerning the state of science, and the public mind in town; unfortunately, there is little to say. I have heard of no important discoveries. In politics, nothing seems capable of exciting permanent interest. The stroke of poverty, though severely felt, has been a torpedo, benumbing all energy, and not irritating and awakening it, as might have been expected.

* In England, politics so constantly mix themselves up with all our institutions, while science unfortunately finds so few disciples and patrons in the ranks of aristocracy, that every new society is viewed with jealousy and party spirit. Johnson says, in his Life of Addison —" It has been suggested that the Royal Society was instituted soon after the Restoration, to divert the attention of the people from public discontent."—P.

Here, at the Pneumatic Institution, the nitrous oxide has evidently been of use. Dr. Beddoes is proceeding in the execution of his great popular physiological work, which, if it equals the plan he holds out, ought to supersede every work of the kind.

I have been pursuing Galvanism with labour, and some success. I have been able to produce galvanic power from simple plates, by effecting on them different oxidating and de-oxidating processes; but on this point I cannot enlarge in the small remaining space of paper.

Your remark concerning *negative* Galvanism, and de-oxidation, is curious, and will most probably hold good.

It will give me much pleasure to see your mathematical Paper* in the Philosophical Transactions, but it will be, unfortunately, to me the pleasure of *blind* sympathy, though derived from the consciousness that you ought to be acting upon, and instructing the world at large.

It will give me sincere pleasure to hear from you, when you are at leisure. After the 11th I shall be in town—my direction, Royal Institution, Albemarle Street. I am, my dear friend, with respect and affection,

Yours,

HUMPHRY DAVY.

The first notice of Davy's name, in the Minute Book of the Royal Institution, occurs in the Report adopted at a Meeting of the Managers, on Monday the 16th of February 1801.

"Resolved—That Mr. Humphry Davy be engaged in the service of the Royal Institution, in the capacities of Assistant Lecturer in Chemistry, Director of the Laboratory, and Assistant Editor of the Journals of the Institution, and that he be allowed to occupy a room in the house, and be furnished with coals and candles; and that he be paid a salary of one hundred guineas per annum."

On the 16th of March 1801, after reporting that "a room had been prepared and furnished for Davy," the Minute proceeds to state that "Mr. Davy had arrived at the Institution on Wednesday the 11th of March, and taken possession of his situation."

It is a curious fact, that the first impression produced on Count Rumford by Davy's personal appearance, was highly unfavourable to the young philosopher, and he expressed to Mr. Underwood his great regret at having been

* He alludes to some calculations connected with light, and the imponderable fluids.

influenced by the ardour with which his suit had been urged; and he actually would not allow him to lecture in the Theatre, until he had given a specimen of his abilities in the smaller lecture-room. His first lecture, however, entirely removed every prejudice which had been formed; and at its conclusion, the Count emphatically exclaimed—"Let him command any arrangements which the Institution can afford." He was accordingly, on the very next day, promoted to the great Theatre.

Davy's uncouth appearance and address subjected him to many other mortifications on his first arrival in London. There was a smirk on his countenance, and a pertness in his manner, which, although arising from the perfect simplicity of his mind, were considered as indicating an unbecoming confidence. Johnson, the publisher, as many of my readers will probably remember, was in the custom of giving weekly dinners to the more distinguished authors and literary stars of the day. Davy, soon after his appointment, was invited upon one of these occasions, but the host actually considered it necessary to explain, by way of apology, to his company, the motives which had induced him to introduce into their society a person of such humble pretensions. At this dinner a circumstance occurred, which must have been very mortifying to the young philosopher. Fuseli was present, and, as usual, highly energetic upon various passages of beauty in the poets, when Davy most unfortunately observed, that there were passages in Milton which he could never understand. "Very likely, very likely, Sir," replied the artist in his broad German accent, "but I am sure that is not Milton's fault."

On the 7th of April, he was elected a member of a society which consisted of twenty-five of the most violent republicans of the day; it was called the "*Tepidarian* Society," from the circumstance of nothing but tea being allowed at their meetings, which were held at Old Slaughter's Coffee House in Saint Martin's Lane. To the influence of this society, Mr. Underwood states that Davy was greatly indebted for his early popularity. Fame gathers her laurels with a slow hand, and the most brilliant talents require a certain time for producing a due impression upon the public; the *Tepidarians* exerted all their personal influence to obtain an audience before the reputation of the lecturer could have been sufficiently known to attract one.

Although the acquaintance between Davy and Count Rumford commenced so inauspiciously, they very soon became friends, and mutually entertained for each other the highest regard.

Davy's improved manners and naturally simple habits, at this period, were highly interesting and exemplary; towards his old friends he conducted himself with the greatest amenity, and frequently consulted them upon certain points connected with his new station in society. The following anecdote was communicated by Mr. Underwood. — "I introduced him," says he, "to my old friend, the excellent Sir Henry Englefield, who was the first intimate acquaintance Davy had formed in the higher circles; he was received by him with all that warmth of manner, and kindness of feeling, which so eminently distinguished him. Shortly after this introduction, Sir Harry sent him an invitation to meet me at dinner. Davy found himself unable to frame an answer to his satisfaction, and fearing he might betray his ignorance of etiquette, ran to my house, and greatly alarmed my mother by the extreme anxiety he displayed, and the manner in which he entreated her to send me to him the moment I returned. I went and found him cudgelling his brains to produce this first attempt at fashionable composition; a dozen answers were on his table, and he was in the highest degree excited and annoyed."

It would appear that, immediately after his arrival at the Royal Institution, he entered upon the duties of his station, and performed them so greatly to the satisfaction of the Managers, that, at a Meeting held on the first of June, not more than six weeks afterwards, the following Resolutions were passed.

"Resolved — That Mr. Humphry Davy, Director of the Chemical Laboratory, and Assistant Lecturer in Chemistry, has, since he has been employed at the Institution, given satisfactory proofs of his talents as a Lecturer.

"Resolved—That he be appointed, and in future denominated, Lecturer in Chemistry at the Royal Institution, instead of continuing to occupy the place of *Assistant* Lecturer, which he has hitherto filled."

From an examination of the Minute Book, it appears that Dr. Garnett, whose health had long been on the decline, resigned his professorship, on the 15th of June,* and that on the 6th of July in the same year, Dr. Young was engaged as Professor of Natural Philosophy, Editor of the Journals, and general Superintendent of the House, at the salary of 300*l.* per annum.

With Dr. Garnett he had lived on terms of great intimacy; with his successor he associated with less ease and freedom.

* He delivered his farewell Lecture on the 9th of the same month.

At a meeting of the Managers, also held in July, several resolutions were passed to the following effect.

"Resolved—That a course of lectures on the Chemical Principles of the Art of Tanning be given by Mr. Davy. To commence the second of November next; and that respectable persons of the trade, who shall be recommended by Proprietors of the Institution, be admitted to these lectures gratis.

"Resolved further—That Mr. Davy have permission to absent himself during the months of July, August, and September, for the purpose of making himself more particularly acquainted with the practical part of the business of tanning, in order to prepare himself for giving the above-mentioned course of lectures."

Davy, it would appear, availed himself of the permission granted to him by the above resolution of the managers, and during the interval visited his native county.

He had arranged with his friend Underwood to make a tour through Cornwall; but as it was his wish to remain at Bristol for a few days, on his way to the West, it was agreed between them that they should meet at Penzance.

Davy, however, became impatient, and wrote the following letter to his friend, a composition of much wildness, and obnoxious to the suspicion of Spinosism.

MY DEAR UNDERWOOD,

THAT part of Almighty God which resides in the rocks and woods, in the blue and tranquil sea, in the clouds and sunbeams of the sky, is calling upon thee with a loud voice; religiously obey its commands, and come and worship with me on the ancient altars of Cornwall.

I shall leave Bristol on Thursday next, possibly before, so that by this day week I shall probably be at Penzance. Ten days or a fortnight after I shall expect to see you, and to rejoice with you.

We will admire together the wonders of God,—rocks and the sea, dead hills and living hills covered with verdure. Amen.

Write to me immediately, and say when you will come. Direct H. Davy, Penzance. Farewell, Being of energy!

Your's with unfeigned affection,

H. DAVY.

Mr. Underwood transmitted to me the above letter with the following extract from his journal.

" On the 25th I went to Bristol, and on the 30th arrived at Mrs. Davy's at Penzance. On the 1st of August we set off on a pedestrian excursion, and proceeded along the edge of the cliffs, round the Land's End, Cape Cornwall, Saint Just, and Saint Ives, to Redruth, and thence back to Penzance.

" Two days afterwards we again started, and trudged along the shore to the Lizard. Kynance Cove had from the commencement of our intimacy been a daily theme of his conversation. No epithets were sufficiently forcible to express his admiration at the beauty of the spot; the enthusiastic delight with which he dwelt upon the description of the Serpentine rocks, polished by the waves, and reflecting the brightest tints from their surfaces, seemed inexhaustible, and when we had arrived at the spot he appeared absolutely entranced.

" During these excursions his conversation was most romantic and poetical. His views of Nature, and her sublime operations, were expressed without reserve, as they rapidly presented themselves to his imagination: they were the ravings of genius; but even his nonsense was that of a superior being."

At the village of Mullion, a little incident occurred, which evinced the existence of that gastronomic propensity which, in after years, displayed itself in a wider range of operations. The tourists had, on their road, purchased a fine large bass of a fisherman, with the intention of desiring the landlady to dress it. On arriving at the inn, Mr. Underwood retired into a room for the purpose of making some notes in the journal he regularly kept. Davy had disappeared. In the course of a few minutes a most tremendous uproar was heard in the kitchen, and the indignant vociferations of the hostess, which, even with all the advantages of Cornish recitative, was not of the most melodious description, became fearfully audible. Davy, it seems, had volunteered his assistance in making the sauce and stuffing for the aforesaid bass; and had he not speedily retreated, his services would have been rewarded, not according to the scientific practice of appending a string of letters to his name, but in conformity with the equally ancient custom of attaching a certain dishonourable addition to the skirts of his jacket.

I have observed that his letter to Mr. Underwood betrayed a tincture of *Spinosism*. It may be here remarked, that during the year 1801 he composed a poem, which he arbitrarily distinguished by that appellation, singularly opposed to the tenor of the sentiments. Through the kindness of Mr. Greenough I possess a copy of it in its original state, for it was subsequently altered, and published in a collection, edited by Miss Johanna Baillie; and still more recently, it underwent farther corrections, and was printed for private circulation in the form in which I shall here introduce it.

Lo! o'er the Earth the kindling spirits pour
The flames of life, that bounteous Nature gives;
The limpid dew becomes the rosy flower;
The insensate dust awakes, and moves, and lives.

All speaks of change: the renovated forms
Of long forgotten things arise again.
The light of suns, the breath of angry storms,
The everlasting motions of the main;

These are but engines of the Eternal Will,
The One Intelligence; whose potent sway
Has ever acted, and is acting still,
Whilst stars, and worlds, and systems, all obey:

Without whose power, the whole of mortal things
Were dull, inert, an unharmonious band;
Silent as are the harp's untuned strings
Without the touches of the poet's hand.

A sacred spark, created by His breath,
The immortal mind of man his image bears;
A spirit living midst the forms of death,
Oppress'd but not subdued by mortal cares—

A germ, preparing in the winter's frost,
To rise and bud and blossom in the spring;
An unfledged eagle by the tempest tost,
Unconscious of his future strength of wing:—

The child of trial, to mortality,
And all its changeful influences given:
On the green earth decreed to move and die;
And yet by such a fate prepared for Heaven.—

Soon as it breathes, to feel the mother's form
  Of orbed beauty, through its organs thrill;
To press the limbs of life with rapture warm,
  And drink of transport from a living rill:

To view the skies with morning radiance bright,
  Majestic mingling with the ocean blue,
Or bounded by green hills, or mountains white;
  Or peopled plains of rich and varied hue:

The nobler charms astonish'd to behold
  Of living loveliness, to see it move,
Cast in expression's rich and varied mould,
  Awakening sympathy, compelling love:—

The heavenly balm of mutual hope to taste,
  Soother of life; affection's bliss to share,
Sweet as the stream amidst the desert waste,
  As the first blush of arctic daylight fair:—

To mingle with its kindred, to descry
  The path of power—in public life to shine;
To gain the voice of popularity;
  The idol of to-day, the man divine:—

To govern others by an influence strong
  As that high law, which moves the murm'ring main;
Raising and carrying all its waves along,
  Beneath the full-orb'd moon's meridian reign:

To scan how transient is the breath of praise;
  A winter's zephyr trembling on the snow,
Chill'd as it moves; or as the northern rays,
  First fading in the centre, whence they flow:—

To live in forests mingled with the whole
  Of natural forms, whose generations rise
In lovely change, in happy order roll
  On land, in ocean, in the glittering skies:—

Their harmony to trace—The Eternal Cause
To know in love, in reverence to adore—
To bend beneath the inevitable law,
Sinking in death ; its human strength no more :—

Then, as awakening from a dream of pain,
With joy its mortal feelings to resign ;
Yet all its living essence to retain,
The undying energy of strength divine :

To quit the burdens of its earthly days,
To give to Nature all her borrow'd powers ;
Ethereal fire to feed the solar rays,
Ethereal dew to glad the earth in showers.

The following letter was written from London, after his return from his Cornish excursion.

TO DAVIES GIDDY, ESQ.

MY DEAR SIR, Royal Institution, Nov. 14, 1801.

After leaving Cornwall in August, I spent about three weeks in Bristol, and at Stowey, so that I did not arrive in London until the 20th of September.

On my arrival I found that Count Rumford had altered his plans of absence, and had left London on that very day for the Continent, purposing to return in about two months. He is now at Paris, and in about a fortnight we expect him here.

I shall soon have an opportunity of submitting Captain Trevitheck's boiler to his observation, and in my next letter I shall give you his opinion of it.

You of course have read an account of Dr. Herschel's experiments on the heat-making rays ; from some late observations it appears, that there are other invisible rays beyond the violet ones, possessed of the *chemical* agency of Light. Sennebier ascertained some time ago that the violet rays blackened muriate of silver in three seconds ; whereas the red rays required, for this effect, twenty minutes. Ritter and Dr. Wollaston have found that beyond the violet rays there is exerted a strong deoxidating action. Muriate of silver placed in the spectrum is not altered beyond the red rays ; but it is instantly blackened when placed on the outside of the violet rays. I purpose to try whether the invisible deoxidating rays will produce light, when absorbed by solar phosphorus.

The most curious galvanic facts lately noticed, are the combustion of gold, silver, and platina. Professor Tromsdorf, by connecting the ends of a moderately strong battery with gold and silver leaf, produced the combustion of them with vivid light. In repeating the experiment on a thin slip of platina, I have produced the same effect.

I yesterday ascertained rather an important fact, namely, that a galvanic battery may be constructed *without any metallic substance!* By means of ten pieces of well-burnt charcoal, nitrous acid, and water, arranged alternately in wine-glasses, I produced all the effects usually obtained from zinc, silver, and water.

The Bakerian Lecture by Dr. Young, our Lecturer on Natural Philosophy, is now reading before the Royal Society. He attempts to revive the doctrine of Huygens and Euler, that light depends upon undulations of an ethereal medium. His proofs (i. e. his presumptive proofs) are drawn from some strong and curious analogies he has discovered between Light and Sound.

I shall strongly hope, now the Peace has arrived, to see you soon in London, as you proposed a tour through the Continent; indeed, you should fix your permanent residence in London, where alone you can do what you ought—instruct and delight numbers of improved men.

I am, my friend, yours
With unfeigned esteem and respect,
HUMPHRY DAVY.

Although during 1801 Davy had given some desultory Lectures, his splendid career cannot be said to have commenced until the following year, when on the 21st of January he delivered his Introductory Lecture, to a crowded and enlightened audience in the Theatre of the Royal Institution; which was afterwards printed at the request of a respectable proportion of the Society.

It contains a masterly view of the benefits to be derived from the various branches of science. He represents the Chemist as the Ruler of all the elements that surround us, and which he employs either for the satisfaction of his wants, or the gratification of his wishes. Not contented with what is to be found on the surface of the earth, he describes him as penetrating into her bosom, and even of searching the depths of the ocean, for the purpose of allaying the restlessness of his desires, or of extending and increasing the boundaries of his power.

In examining the science of Chemistry, with regard to its great agency in the improvement of society, he offers the following almost prophetic remarks. "Unless any great physical changes should take place upon the globe, the permanency of the Arts and Sciences is rendered certain, in consequence of the diffusion of knowledge, by means of the invention of Printing; and by which those words which are the immutable instruments of thought, are become the constant and widely diffused nourishment of the mind, and the preservers of its health and energy."

"Individuals influenced by interested motives or false views, may check for a time the progress of knowledge;—moral causes may produce a momentary slumber of the public spirit;—the adoption of wild and dangerous theories, by ambitious or deluded men, may throw a temporary opprobrium on literature; but the influence of true philosophy will never be despised; the germs of improvement are sown in minds, even where they are not perceived; and sooner or later, the spring-time of their growth must arrive.

"In reasoning concerning the future hopes of the human species, we may look forward with confidence to a state of society, in which the different orders and classes of men will contribute more effectually to the support of each other than they have hitherto done. This state, indeed, seems to be approaching fast; for, in consequence of the multiplication of the means of instruction, the man of science and the manufacturer are daily becoming more assimilated to each other. The artist, who formerly affected to despise scientific principles, because he was incapable of perceiving the advantages of them, is now so far enlightened as to favour the adoption of new processes in his art, whenever they are evidently connected with a diminution of labour; and the increase of projectors, even to too great an extent, demonstrates the enthusiasm of the public mind in its search after improvement.

"The arts and sciences, also, are in a high degree cultivated and patronized by the rich and privileged orders. The guardians of civilization and of refinement, the most powerful and respected part of society, are daily growing more attentive to the realities of life; and giving up many of their unnecessary enjoyments, in consequence of the desire to be useful, are becoming the friends and protectors of the labouring part of the community.

"The unequal division of property and of labour, the differences of rank and condition amongst mankind, are the sources of power in civilized life—its moving causes, and even its very soul. In considering and hoping that the human species is capable of becoming more enlightened and more happy, we can only expect that the different parts of the great whole of society should be intimately united together, by means of knowledge and the useful arts; that they should act as the children of one great parent, with one determinate end, so that no power may be rendered useless—no exertions thrown away.

"In this view, we do not look to distant ages, or amuse ourselves with brilliant though delusive dreams, concerning the infinite improveability of man, the annihilation of labour, disease, and even death, but we reason by analogy from simple facts, we consider only a state of human progression arising out of its present condition,—we look for a time that we may reasonably expect—FOR A BRIGHT DAY, OF WHICH WE ALREADY BEHOLD THE DAWN."

The extraordinary sensation produced amongst the members of the Institution by this first course of lectures, has been vividly described by various persons who had the good fortune to be his auditors; and foreigners have recorded in their travels the enthusiasm with which the great English chemist had inspired his countrymen.

The members of the Tepidarian Society, sanguine in the success of their child,—for so they considered Davy,—purposely appointed their anniversary festival on the day of his anticipated triumph. They were not disappointed in their hopes; and their dinner was marked by every demonstration of hilarity. In the evening, Davy accompanied by a few friends, attended, for the first time in his life, a masquerade which was given at Ranelagh.

On the following day, he dined with Sir Harry Englefield. I have a copy of the invitation, addressed to Mr. Underwood, now before me.

DEAR UNDERWOOD,

DAVY, covered with glory, dines with me to-day at five. If you could meet him it would give me great pleasure.

Yours truly,
H. C. ENGLEFIELD.

Tilney Street, Friday.

At this dinner, Sir Harry wrote a request to Davy to print his Lecture, which was signed by every one present, except Mr. Underwood, who declined, from the apprehension that the signature of so intimate a friend might give to that which was a spontaneous homage to talent, the appearance of a previously concerted scheme.

I shall here weave into my narrative some extracts from several letters, with which Mr. Purkis, one of the earliest friends of Davy, has lately favoured me.

" On his first appointment at the Royal Institution, I was specially introduced to him by a common friend, Thomas Poole, Esq. of Nether Stowey in Somersetshire; and I continued in habits of friendship with him during a great portion of his life, though somewhat less intimately during the last few years. I loved him living—I lament his early death: I shall ever honour his memory.

" The sensation created by his first course of Lectures at the Institution, and the enthusiastic admiration which they obtained, is at this period scarcely to be imagined. Men of the first rank and talent,—the literary and the scientific, the practical and the theoretical, blue-stockings, and women of fashion, the old and the young, all crowded—eagerly crowded the lecture-room. His youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations and well-conducted experiments, excited universal attention and unbounded applause. Compliments, invitations, and presents, were showered upon him in abundance from all quarters; his society was courted by all, and all appeared proud of his acquaintance.

" One instance of attention is particularly recalled to my memory. A talented lady, since well known in the literary world, addressed him anonymously in a poem of considerable length, replete with delicate panegyric and genuine feeling. It displayed much originality, learning, and taste; the language was elegant, the versification harmonious, the sentiments just, and the imagery highly poetical. It was accompanied with a handsome ornamental appendage for the watch, which he was requested to wear when he delivered his next lecture, as a token of having received the poem, and pardoned the freedom of the writer. It was long before the fair authoress was known to him, but they afterwards became well acquainted with each other."

I should not redeem the pledge given to my readers, nor fulfil the duties of an impartial biographer, were I to omit acknowledging that the manners and habits of Davy very shortly underwent a considerable change. Let those who have vainly sought to disparage his excellence, enjoy the triumph of knowing that he was not perfect; but it may be asked in candour, where is the man of twenty-two years of age, unless the temperature of his blood were below zero, and his temperament as dull and passionless as the fabled god of the Brahmins, who could remain uninfluenced by such an elevation? Look at Davy in the laboratory at Bristol, pursuing with eager industry various abstract points of research; mixing only with a few philosophers, sanguine like himself in the investigation of chemical phenomena, but whose sphere of observation must have been confined to themselves, and whose worldly knowledge could scarcely have extended beyond the precincts of the Institution in which they were engaged. Shift the scene—behold him in the Theatre of the Royal Institution, surrounded by an aristocracy of intellect as well as of rank; by the flowers of genius, the *élite* of fashion, and the beauty of England, whose very respirations were suspended in eager expectation to catch his novel and satisfactory elucidations of the mysteries of Nature. Could the author of the Rambler have revisited us, he would certainly have rescinded the passage in which he says—"All appearance of science is hateful to women; and he who desires to be well received by them, must qualify himself by a total rejection of all that is rational and important; must consider learning as perpetually interdicted, and devote all his attention to trifle, and all his eloquence to compliment."

It is admitted that his vanity was excited, and his ambition raised, by such extraordinary demonstrations of devotion; that the bloom of his simplicity was dulled by the breath of adulation; and that, losing much of the native frankness which constituted the great charm of his character, he unfortunately assumed the garb and airs of a man of fashion; let us not wonder if, under such circumstances, the inappropriate robe should not always have fallen in graceful draperies.

At length, so popular did he become, under the auspices of the Duchess of Gordon and other leaders of high fashion, that even their *soirées* were considered incomplete without his presence; and yet these fascinations, strong as they must have been, never tempted him from his allegiance to Science; never did the charms of the saloon allure him from the pursuits of the laboratory, or distract him from the duties of the lecture-room. The crowds that repaired to the Institution in the morning were, day after day, gratified by newly devised and highly illustrative experiments, conducted with the utmost address, and explained in language at once perspicuous and eloquent.

He brought down Science from those heights which were before accessible only to a few, and placed her within the reach of all; he divested the goddess of all severity of aspect, and represented her as attired by the Graces.

It is perhaps not possible to convey a better idea of the fascination of his style, than by the relation of the following anecdote. A person having observed the constancy with which Mr. Coleridge attended these lectures, was induced to ask the poet what attractions he could find in a study so unconnected with his known pursuits. "I attend Davy's lectures," he replied, "to increase my stock of metaphors."

But, as Johnson says, in the most general applause some discordant voices will always be heard; and so was it upon the present occasion. It was urged by several modern *Zoili*, that the style was far too florid and imaginative for communicating the plain lessons of truth; that he described objects of Natural History by inappropriate imagery, and that violent conceits frequently usurped the place of philosophical definitions. This was Bœotian criticism; the Attic spirits selected other points of attack; they rallied him on the ground of affectation, and whimsically represented him as swayed by a mawkish sensibility, which constantly betrayed him into absurdity. There might be some shew of justice in this accusation: The world was not large enough to satisfy the vulgar ambition of the conqueror, but the minutest production of nature afforded ample range for the scrutinising intelligence of the philosopher; and he would consider a particle of crystal with so delicate a regard for its minute beauties, and expatiate with so tender a tone of interest on its fair proportions, as almost to convey an idea that he bewailed the condition of necessity which for ever allotted it so slender a place in the vast scheme of creation.

After the observations which have been offered with regard to the injurious tendency of metaphors in all matters relating to science, I may probably be charged with inconsistency in defending Davy from the attacks thus levelled against his style. We need not the critic to remind us that the statue of a Lysippus may be spoiled by gilding; but I would observe that the style which cannot be tolerated in a philosophical essay, may under peculiar circumstances be not only admissible, but even expedient, in a popular lecture. "*Neque ideo minus efficaces sunt orationes nostræ quia ad aures judicantium cum voluptate perveniunt. Quid enim si infirmiora horum temporum templa credas, quia non rudi cæmento, et informibus tegulis exstruuntur; sed marmore nitent et auro radiantur?*"

Let us consider, for a moment, the class of persons to whom Davy addressed himself. Were they students prepared to toil with systematic precision, in order to obtain knowledge as a matter of necessity?—No—they were composed of the gay and the idle, who could only be tempted to admit instruction by the prospect of receiving pleasure,—they were children, who could only be induced to swallow the salutary draught by the honey around the rim of the cup.

It has been well observed, that necessity alone can urge the traveller over barren heaths and snow-topped mountains, while he treads with rapture along the fertile vales of those happier climes where every breeze is perfume, and every scene a picture.

If Science can be promoted by increasing the number of its votaries, and by enlisting into its service those whom wealth and power may render valuable as examples or patrons, there does not exist a class of philosophers to which we are more largely indebted than to popular lecturers, or to those whose eloquence has clothed with interest, subjects otherwise severe and uninviting. How many disciples did Mineralogy acquire through the lectures of Dr. Clarke at Cambridge, who may truly be said to have covered a desert with verdure, and to have raised from barren rocks, flowers of every hue and fragrance! In the sister university, what an accession of strength and spirit have the animated discourses of Dr. Buckland brought to the ranks of Geologists! To judge fairly of the influence of a popular style, we should acquaint ourselves with the effects of an opposite method; and if an appeal be made to experience, I may very safely abide the issue. Dr. Young, whose profound knowledge of the subjects he taught, no one will venture to question, lectured in the same theatre, and to an audience similarly constituted as that which was attracted by Davy, but he found the number of his attendants to diminish daily, and for no other reason than that he adopted too severe and didactic a style.*

In speaking of Davy's lectures as mere specimens of happy oratory, we do injustice to the philosopher; had he merely added the Corinthian foliage to a temple built by other hands, we might have commended his taste, and admired his talent of adaptation; and there our eulogium must have ended; but the edifice itself was his own, he dug the materials from the quarry, formed them

* From the following minute it would appear, that Dr. Young's connection with the Royal Institution was but of short duration. It will be remembered that his appointment took place on July 6, 1801.

"Resolved—That Dr. Young be paid the balance of two years' complete salary, and that his engagement with the Institution terminate from this time—July 4, 1803."

into a regular pile, and then with his masterly touch added to its strength beauty, and to its utility grace.

In addition to these morning lectures, we find that he was also engaged in delivering a course in the evening; of which the following notice is extracted from one of the scientific journals of the time.—"On the 25th, Mr. Davy commenced a course of lectures on Galvanic phenomena. Sir Joseph Banks, Count Rumford, and other distinguished philosophers, were present. The audience were highly gratified, and testified their satisfaction by general and repeated applause.

"Mr. Davy, who appears to be very young, acquitted himself admirably. From the sparkling intelligence of his eye, his animated manner, and the *tout ensemble*, we have no doubt of his attaining a very distinguished eminence."

From a Minute entered on the Records of the Institution, it appears that, at a meeting of Managers held on the 31st of May 1802, it was moved by Sir Joseph Banks, and seconded by Mr. Sullivan,—

"That Mr. Humphry Davy be for the future styled *Professor of Chemistry* to the Royal Institution."

A sufficient proof of the universal feeling of admiration which his lectures had excited.

The success of his exertions is communicated by him to his early friend, in the following letter.

TO DAVIES GIDDY, ESQ.

DEAR FRIEND,

SINCE the commencement of the Session at the Institution, I have had but few moments of leisure. The composition of a first course of lectures, and the preparation for experiments, have fully occupied my time; and the anxieties and hopes connected with a new occupation have prevented me from paying sufficient attention even to the common duties and affections of life. Under such circumstances, I trust you will pardon me for having suffered your letters to remain so long unanswered. In human affairs, anticipation often constitutes happiness; your correspondence is to me a real source of pleasure, and believe me, I would suffer no opportunity to escape of making it more frequent and regular.

My labours in the theatre of the Royal Institution have been more successful than I could have hoped from the nature of them. In lectures, the effect produced upon the mind is generally transitory; for the most part, they amuse rather than instruct, and stimulate to inquiry rather than give information. My audience has often amounted to four and five hundred, and upwards; and amongst them some promise to become permanently attached to Chemistry. This science is much the fashion of the day.

Amongst the latest scientific novelties, the two new planets occupy the attention of Astronomers, while Natural Philosophers and Chemists are still employed upon Galvanism.

In a paper lately read before the Royal Society, Dr. Herschel examines the magnitudes of the bodies discovered by Mr. Piazzi and Dr. Olbers. He supposes the apparent diameter of Ceres to be about 22″, and that of Pallas, 17″ or 13″, so that their real diameters are 163, and 95 or 71 English miles —How small! The Doctor thinks that they differ from planets in their general character, as to their diminutive size, the great inclination of their orbits, the coma surrounding them, and as to the proximity of their orbits.— From comets, in their want of their eccentricity, and any considerable nebulosity. He proposes to call them *Asteroids.*

I mentioned to you in a former letter the great powers of Galvanism in effecting the combustion of metals. I have lately had constructed for the laboratory of the Institution, a battery of immense size; it consists of four hundred plates of five inches in diameter, and forty, of a foot in diameter. By means of it, I have been enabled to inflame cotton, sulphur, resin, oil, and ether; it fuses platina wire, and makes red hot and burns several inches of iron wire of 1-300th of an inch in diameter; it easily causes fluid substances, such as oil and water, to boil, decompounds them, and converts them into gases. I am now examining the agencies of it upon certain substances that have not as yet been decomposed, and in my next letter I hope to be able to give you an account of my experiments.

I shall hope soon to hear that the roads of England are the haunts of Captain Trevitheck's dragons. You have given them a characteristic name.

I wish any thing would happen to tempt you to visit London. You would find a number of persons very glad to see you, with whose attentions you could not be displeased. With unfeigned respect,

Yours sincerely,

H. Davy.

It is perhaps not possible to imagine a greater contrast, than between the elegant manner in which Davy conducted his experiments in the theatre, and the apparently careless and slovenly style of his manipulations in the laboratory; but in the one case he was communicating knowledge, in the other, obtaining it. Mr. Purkis relates an anecdote very characteristic of this want of refinement in his working habits. "On one occasion, while reading over to me an introductory lecture, and wishing to expunge a needless epithet, instead of taking up the pen, he dipped his forefinger into the ink bottle, and thus blotted out the unmeaning expletive."

It was his habit in the laboratory, to carry on several unconnected experiments at the same time, and he would pass from one to the other without any obvious design or order; upon these occasions he was perfectly reckless of his apparatus, breaking and destroying a part, in order to meet some want of the moment. So rapid were all his movements, that, while a spectator imagined he was merely making preparations for an experiment, he was actually obtaining the results, which were just as accurate as if a much longer time had been expended. With Davy, rapidity was power.

The rapid performance of intellectual operations was a talent which displayed itself at every period of his life. We have heard with what extraordinary rapidity he read at the age of five years; and we now learn that his chemical enquiries were conducted with similar facility and quickness.

His early friend Mr. Poole bears his testimony to the existence of the same quality in the following passage, extracted from a letter I had lately the favour of receiving from him. "From my earliest knowledge of my admirable friend, I consider his most striking characteristic to have been the quickness and truth of his apprehension. It was a power of reasoning so rapid, when applied to any subject, that he could hardly be himself conscious of the process; and it must, I think, have been felt by him, as it appeared to me, pure intuition. I used to say to him, 'You understand me before I half understand myself?'

"I recollect on our first acquaintance, he knew but little of the practice of agriculture. I was at that time a considerable farmer, and very fond of the occupation. During his visits in those days, I was at first something like his teacher, but my pupil soon became my master both in theory and practice."

The chemical manipulations of Wollaston and Davy offered a singular contrast to each other, and might be considered as highly characteristic of the temperaments and intellectual qualities of these remarkable men. Every process of the former was regulated with the most scrupulous regard to microscopic accuracy, and conducted with the utmost neatness of detail. It has been already stated with what turbulence and apparent confusion the experiments of the latter were conducted; and yet each was equally excellent in his own style; and, as artists, they have not unaptly been compared to Teniers and Michael Angelo. By long discipline, Wollaston had acquired such power in commanding and fixing his attention upon minute objects, that he was able to recognise resemblances, and to distinguish differences, between precipitates produced by re-agents which were invisible to ordinary observers, and which enabled him to submit to analysis the minutest particle of matter with success. Davy, on the other hand, obtained his results by an intellectual process, which may be said to have consisted in the extreme rapidity with which he seized upon, and applied, appropriate means at appropriate moments.

Many anecdotes might be related, in illustration of the curiously different structure of the minds of these two ornaments of British Science. The reader will, in the course of these memoirs, be furnished with sufficient evidence of the existence of those qualities which I have assigned to Davy; another biographer will no doubt ably illustrate those of Dr. Wollaston.

I shall only observe, that to this faculty of minute observation, which Dr. Wollaston applied with so much advantage, the chemical world is indebted for the introduction of more simple methods of experimenting,—for the substitution of a few glass tubes, and plates of glass, for capacious retorts and receivers, and for the art of making grains give the results which previously required pounds. A foreign philosopher once called upon Dr. Wollaston with letters of introduction, and expressed an anxious desire to see his laboratory. "Certainly," he replied; and immediately produced a small tray containing some glass tubes, a blow-pipe, two or three watch-glasses, a slip of platinum, and a few test bottles.

Wollaston appeared to take great delight in shewing by what small means he could produce great results. Shortly after he had inspected the grand galvanic battery constructed by Mr. Children, and had witnessed some of those brilliant phenomena of combustion which its powers produced, he accidentally met a brother chemist in the street, and seizing his button, (his constant habit when speaking on any subject of interest,) he led him into a secluded corner; when taking from his waistcoat pocket a tailor's thimble, which contained a galvanic arrangement, and pouring into it the contents of a small phial, he instantly heated a platinum wire to a white heat.

There was another peculiarity connected with Wollaston's habit of minute observation; it enabled him to press into his service, at the moment, such ordinary and familiar materials as would never have occurred to less observing chemists. Mr. Brande relates an anecdote admirably calculated to exemplify this habit. He had called upon Dr. Wollaston to consult him upon the subject of a calculus;—it will be remembered that neither phosphate of lime, constituting the '*bone earth*' species, nor the ammoniaco-magnesian phosphate, commonly called the '*triple phosphate*,' is *per se* fusible; but that when mixed, these constitute the '*fusible calculus*' which readily melts before the blow-pipe.—Dr. Wollaston, on finding the substance under examination refractory, took up his paper folder, and scraping off a fragment of the ivory, placed it on the specimen, when it instantly fused.

Having contrasted the manipulations of Davy, as exhibited in the theatre, with those performed by him in the laboratory, it may, in this place, be interesting to offer a few remarks upon the difference of his style as a lecturer and as a writer. Whatever diversity of opinion may have been entertained as to the former, I believe there never was but one sentiment with respect to the latter. There is an ethereal clearness of style, a simplicity of language, and, above all, a freedom from technical expression, which render his philosophical memoirs fit studies and models for all future chemists. Mr. Brande, in a late lecture delivered before the members of the Royal Institution, very justly alluded to this latter quality of his writings, and forcibly contrasted it with the system of Berzelius, of whom it is painful to speak but in terms of the most profound respect, and yet it is impossible not to express a deep regret at this distinguished chemist's introduction of a system of technical expressions, which from its obscurity is calculated to multiply rather than to correct error, and from its complications, to require more labour than the science to which it administers: to apply the quaint metaphor of Locke, "it is no more suited to improve the understanding than the move of a jack is to fill our bellies."

From the readiness with which some continental chemists have adopted such terms, and from the spirit in which they have defended them, one might almost be led to suspect that they believed them, like the words used by the Magi of Persia, to possess a cabalistic power. Davy foresaw the injury which science must sustain from such a practice, and endeavoured, both by precept and example, to discountenance it.

With regard to the introduction of a figurative and ornamental style into memoirs purely scientific, no one could entertain a more decided objection; and in his " last days," he warns us against the practice.

" In detailing the results of experiments, and in giving them to the world, the chemical philosopher should adopt the simplest style and manner; he will avoid all ornaments, as something injurious to his subject, and should bear in mind the saying of the first king of Great Britain, respecting a sermon which was excellent in doctrine, but overcharged with poetical allusions and figurative language,—" that the tropes and metaphors of the speaker were like the brilliant wild flowers in a field of corn, very pretty, but which did very much hurt the corn."

CHAPTER IV.

Davy makes a tour with Mr. Purkis, through Wales.—Beautiful phenomenon observed from the summit of Arran Benllyn.—Letter to Mr. Gilbert.—Journal of the Institution.—Davy's papers on Eudiometry, and other subjects.—His first communication to the Royal Society, on a new galvanic pile.—He is proposed as a Fellow, and elected into the Society.—His paper on astringent vegetable substances, and on their operation in tanning leather.—His letter to Mr. Poole.—He is appointed Chemical Lecturer to the Board of Agriculture.—He forms friendships with the Duke of Bedford, Mr. Coke, and many other celebrated agriculturists.—Attends the sheep-shearing at Holkham and Woburn.—Composes a Prologue to the "Honey-Moon."

After the fatigues and anxieties of his first session, Davy sought relaxation and repose amidst the magnificent scenery of Wales. The following letter will serve more fully to exhibit the enthusiasm he experienced in contemplating Nature in her wild and simplest forms.

TO SAMUEL PURKIS, ESQ.

MY DEAR FRIEND, Matlock, August 15, 1802.

Had I been alone, and perfectly independent as to my plans, I should probably have written to you long ago. I should have begged you to hasten your departure, so that we might have rejoiced together in Wales, under the influence of that moon which is now full in all its glory; for Derbyshire, taken as a whole, has not pleased me. A few beautiful valleys, placed at the distance of many miles from each other, do not compensate for the almost uniform wildness and brown barrenness of the hills and plains; and in the watering places, there is little amongst the *living beings* to awaken deep moral feelings, or to call the nobler powers of the mind, which act in consequence of sympathy, into existence.

I have longed for the mountain scenery, and for the free inhabitants of North Wales; and even the majestic valleys of the Wye and the Derwent have been to me but typical of something more perfect in beauty and grandeur.

Whenever it shall seem fitting to you, I shall be prepared for our long contemplated journey, and do not delay your departure;—*before* the 21st would be more agreeable to me than *after* that period; and then we shall be able to view the horns of the next moon, where they are most beautiful.

I have enquired much concerning Dove-dale, since I have been here, and, from the most accurate accounts, I am inclined to believe that it is inferior, in point of sublime scenery, to *Chee Tor*, near Bakewell, and in beauty, to the valley of the *Great Tor*, in which I am now writing. On the whole, I think your best plan will be to meet me at Matlock, which you must see, and then in our route to Buxton, we can visit the valley of the Wye, and the most noble *Chee Tor*.

Concerning the excursion of Dove-dale, I am undecided, and it shall depend upon you to determine with regard to it.

As one great object in our excursions is to view Nature and man in their most simple forms, and to gain a temporary life of new impressions, I submit to you whether it will not be best to steer clear of *towns*, *cities*, and *civilized society*, in which, for the most part, we can see what we have only seen before.

If we visit Sir Joseph Banks, it certainly should be only *en passant*: and to see that most excellent personage, and to be obliged to quit him immediately, will be at least painful; for the respectful feelings he produces in the mind are always modified by affection.

I have no room to give you the quantity of information that I have gained concerning the places and people of Wales; this shall serve for our Derbyshire chat. I thank you much for your last kind letter, which gave me high pleasure. You possess the true spirit of composition, which embodies facts in words.

I am, &c.

H. Davy.

I am informed by Mr. Purkis, that in the latter end of this summer, he made a pedestrian tour with Davy, through North and South Wales, and he has transmitted to me the following account of this excursion.—" We visited every place possessing any remains of antiquity, any curious productions of nature or art, and every spot distinguished by romantic and picturesque scenery. Our friend's diversified talents, with his knowledge of Geology, and

Natural History in general, rendered him a most delightful companion in a tour of this description. Every mountain we beheld, and every river we crossed, afforded a fruitful theme for his scientific remarks. The form and position of the mountain, with the several *strata* of which it was composed, always procured for me information as to its character and classification; and every bridge we crossed invariably occasioned a temporary halt, with some appropriate observations on the productions of the river, and on the diversion of angling.

" In one of our morning excursions in North Wales, we ascended the summit of *Arran Benllyn*, a celebrated mountain, inferior only to Snowdon and Cader Idris, a few miles from the lake of Bala. Here we were fortunate in beholding a scene of extraordinary sublimity, seldom witnessed in this climate. From the top of this mountain we looked down, about mid-day, on a deep valley eight or ten miles in length, and as many in breadth, the whole of which, for a considerable height from the surface of the ground, was filled with beautiful clouds, while the atmosphere around the summit on which we stood was perfectly clear, and the sky above us of a deep blue colour. The clouds in the valley were in irregular, gentle undulations, dense, compact, and continuous, of that kind which is denominated by Meteorologists, *cirro-cumulus*, and by the vulgar, *woolpack* clouds, such as are often seen in the higher regions on a fine summer's day. The sun shone with great brilliancy, and illumined their various forms with silver, grey and blue tints of exquisite beauty. As there was scarcely a breath of air stirring below the mountain, this aggregation of clouds, probably occasioned by some electrical agency, remained fixed and stationary, as if identified with the valley. The higher parts of most of the surrounding hills were enveloped in mist, above which the tops of *Snowdon* and *Cader Idris* towered distinctly visible, and appeared like small islands rising out of the sea. This scene altogether was one of inexpressible magnificence and grandeur, filling the mind with awe and rapture. We seemed to feel ourselves like beings of a higher order in a celestial region, looking down on the lower world with conscious superiority.

" After sitting and ruminating on this sublime spectacle for two or three hours, we left the summit of the mountain with reluctance, and, slowly descending, rested at intervals, and often cast a longing, lingering look behind.

"On reaching our comfortable inn at Bala, while waiting for dinner, Davy walked about the room, and, as if by inspiration, broke out in a beautiful impassioned apostrophe on the striking scene we had so recently witnessed. It was in a kind of unmeasured blank verse, highly animated and descriptive, at once poetical and philosophical. At the conclusion of this eloquent effusion, I endeavoured to recollect and commit it to writing, but I could not succeed, and Davy was too modest to assist my memory.

"In a tour through North Wales, where the few small inns have seldom any spare rooms, different parties are often obliged to sit in the same apartment, and to eat at the same table. Hence we were occasionally introduced to characters of various descriptions, some of whom gratified us by their agreeable qualities, while others disgusted us by their ignorance and impertinence. On one occasion, after a heavy shower of rain in the middle of August, we were drying our clothes by the fire in the little Inn at *Tan y Bwlch*, when the landlord requested us to admit a gentleman, who was very wet. A young man, of pleasing appearance and manner, was then introduced, and after some common-place observations, we sat down to dinner. The stranger was evidently a man of education and acquirements, and after the cloth had been removed, he began to discourse very fluently on scientific subjects. He talked of oxygen and hydrogen, of hornblende, and the *Grawacké* of Werner, and geologists, in the most familiar tone of self-complacency.

"Davy's youth, simplicity of manner, and cautious concealment of superior knowledge, not exciting constraint, our companion was naturally induced to deliver his opinions with the utmost freedom and confidence on all subjects. We commenced on poetry and painting; the sublime and beautiful; then proceeded to mineralogy, astronomy, &c. and occasionally digressed on topics of mirth and humour, so that the evening was passed with general satisfaction.

"When Davy had retired to rest, and I was left alone with our companion, I enquired how he liked my friend, and whether he considered him a proficient in science, and versed in chemistry and geology? He answered coolly that 'he appeared to be rather a clever young man, with some general scientific knowledge.' He then asked his name, and when I announced 'Davy, of the Royal Institution,' the stranger seemed thunderstruck, and exclaimed, 'Good God! was that really Davy? How have I exposed my ignorance and presumption!' It is scarcely necessary to add, that at the breakfast table the next morning, he talked on subjects of science with less volubility than on the preceding evening."

After Davy's return from this expedition, he wrote the following letter.

TO DAVIES GIDDY, ESQ.

MY DEAR SIR, Royal Institution, October 26, 1802.

It is long since I have had the pleasure of hearing from you. You probably received a hasty letter that I wrote to you in the beginning of the summer. Since that period I have been idling away much of my time in Derbyshire and North Wales.

Till very lately, I had hoped of being able to spend a few weeks of the autumn in Cornwall, but I now find that it will not suit with my occupations. Not having it in my power to see you, you may believe that I am most anxious to hear from you.

We hear, at this time, in London of comparatively few scientific novelties. The wonders of revolutionized Paris occupy many of our scientific men; and the summer and autumn are not the working seasons in great cities. The rich and fashionable part of the community think it their duty to kill time in the country, and even philosophers are more or less influenced by the spirit of the times.

In the last volume of the Manchester Memoirs, *i. e.* the fifth, are some papers of Mr. Dalton on the Constitution of the Atmosphere; on the expansive powers of Steam; and on the dilatation of Elastic Fluids by Heat. As far as I can understand his subjects, the author appears to me to have executed them in a very masterly way. I wish very much to have your judgment upon his opinions, some of which are new and very singular.

Have you yet seen the theory of my colleague, Dr. Young, on the undulations of an Ethereal Medium as the cause of Light? It is not likely to be a popular hypothesis after what has been said by Newton concerning it. He would be very much flattered if you could offer any observations upon it, whether for or against it. The paper is in the last volume of the Transactions.

I believe I mentioned to you in a former letter that *Terra Japonica*, or *Extractum Catechu*, contained a very large proportion of the tanning principle. My friend Mr. Purkis, an excellent practical tanner, has lately tried some experiments upon it in the large way. It answers very well, and I am now wearing a pair of shoes, the leather of one of which was tanned with oak-bark, and that of the other with *Terra Japonica;* and they appear to be equally good. We are in great hopes that the East India Company will consent to the importation of this article. One pound of it goes at least as far as nine pounds of oak-bark; and it could certainly be rendered in England for less than four-pence the pound: oak-bark is nearly one penny per pound.

The *Zoonic acid,* which M. Berthollet supposed to be a peculiar acid, has been lately shewn by M. Thenard to be only acetous acid, holding a peculiar animal matter in solution.

Gregory Watt is just returned from the Continent, where he has passed the last fifteen months. He has been much delighted with his excursion, but his health is at present bad. I trust, however, that English roast-beef and English customs will speedily restore it.

We are publishing, at the Royal Institution, a Journal of Science, which contains chiefly abridged accounts of what is going on in different parts of Europe, with some original papers; and in hopes that its diffusion may become more general, we have fixed its price at one shilling. As soon as I have an opportunity, I will send you the last numbers of it.

I am beginning to think of my Course of Lectures for the winter. In addition to the common course of the Institution, I have to deliver a few lectures on Vegetable Substances, and on the connexion of Chemistry with Vegetable Physiology, before the Board of Agriculture. I have begun some experiments on the powers of soils to absorb moisture, as connected with their fertility. I have, for this purpose, made a small collection of those of the *calcareous* and *secondary* countries, and I wish very much for some specimens from the *granitic* and *schistose* hills of Cornwall. If you could, without much trouble, cause to be procured from your estates different pieces of uncultivated soil, of about a pound weight each, I should feel much obliged to you. They should be accompanied by specimens of the stone or strata on which they lie.

I am, dear Sir, with affection and respect,

Yours,

H. Davy.

Of the Journals alluded to in the above letter, it would seem that Davy and Dr. Young were the joint editors. The former appears both as a reviewer and an original writer, and in each capacity we recognise the peculiarities of his genius; in the one case, by the quickness with which he detects error; and in the other, by the avidity with which he apprehends truth.

It will not be uninteresting to take a short review of his original communications, especially as the work has become extremely scarce; indeed, as it was published in numbers, it is very probable that only a few copies have escaped the common fate of periodicals.

His first paper is entitled, "An Account of a New Eudiometer," and has for its principal object the recommendation of the solution of the green muriate, or sulphate of iron, impregnated with *nitrous* gas; the knowledge of the properties of which, in absorbing oxygen gas, arose out of those experiments to which an allusion has been already made.*

This test is prepared by transmitting a current of nitrous gas through a saturated solution of the salt of iron. As the absorption of the gas proceeds, the solution acquires the colour of a deep olive-brown; and when the impregnation is completed, it appears opaque and almost black. The process is apparently owing to a simple elective attraction; in no case is the gas decomposed; and under the exhausted receiver it resumes its elastic form, leaving the fluid with which it was combined, unaltered in its properties. The test, therefore, can only be regarded as a convenient modification of that of Priestley, in which the nitrous gas was presented to the atmospheric air to be examined, without the intervention of any third body.

The only apparatus required for the application of the test, as suggested by Davy, is a small graduated tube, having its capacity divided into one hundred parts, and a vessel for containing the fluid. The tube, after being filled with the air to be examined, is introduced into the solution, and shaken in contact with it; when the air will be rapidly diminished in volume, and the whole of its oxygen, in a few minutes, condensed into nitrous acid.

By means of this test, Davy informs us that he examined the atmosphere in different places, without being able to ascertain any notable difference in the proportions of its component parts.

Twenty-eight years have elapsed since the publication of this paper; and yet, amidst the rapid progress of discovery, Eudiometry has not been able even to modify the results it has given us; but the reader will be pleased to remember, that by these tests it is only professed to shew the relative proportions of oxygen in air; the salubrity of an atmosphere depends upon many other causes, especially its condition with regard to moisture, which, in a variety of ways, exerts an influence upon the structures of the body.

* See page 60.

In this Journal we also find several original communications from Davy on galvanic phenomena, which will be noticed on a future occasion. There is likewise a paper of considerable interest, entitled, "An Account of a method of copying Paintings upon Glass, and of making Profiles, by the agency of Light upon Nitrate of Silver, invented by T. Wedgwood, Esq.; with Observations by H. Davy."

In the first place, he gives an account of the experiments of Mr. Wedgwood, and then, with his usual sagacity, extends our knowledge of the subject by his own researches.

Chemists had been long acquainted with the fact, that white paper, or white leather, moistened with a solution of the *nitrate of silver*, although it does not undergo any change when kept in a dark place, will speedily change colour on being exposed to daylight; and that, after passing through different shades of grey and brown, it will at length become nearly black. These alterations in colour take place more speedily in proportion as the light is more intense. In the direct beams of the sun, two or three minutes are sufficient; in the shade, several hours are required to produce the full effect; and light transmitted through differently coloured glass, acts upon it with different degrees of intensity. It is found, for instance, that red rays, or the common sunbeams passed through red glass, have very little action upon it; yellow and green are more efficacious; but blue and violet produce the most decided and powerful effects. Davy observes that these facts were analogous to those which were long ago observed by Scheele, and confirmed by Senebier.

To Mr. Wedgwood, however, belongs the merit of having first applied them for the ingenious purpose of copying engravings, &c. His first attempt was to copy the images formed by the *camera obscura*, but they were found to be too faint to produce, in any moderate time, the necessary changes upon the *nitrate of silver*. With paintings on glass he was more successful; for the copying of which, the solution should be applied on leather, which is more readily acted upon than paper. When a surface thus prepared is placed behind a painting on glass, exposed to the solar light, the rays transmitted through the differently coloured surfaces produce distinct tints of brown or black, sensibly differing in intensity, according to the shades of the picture, and where the light is unaltered, the colour of the *nitrate* becomes deepest.

Besides this application of the method of copying, there are many others. It may be rendered subservient for making delineations of all such objects as are possessed of a texture partly opaque, and partly transparent; such, for instance, as the woody fibres of leaves, and the wings of insects; for which purpose, it is only necessary to cause the direct solar light to pass through them, and to receive the shadows upon prepared leather.

To Davy we are indebted for an extremely beautiful application of this principle,—that of copying small objects produced by means of the solar microscope. For the success, however, of this experiment, it is necessary that the prepared leather should be placed at a small distance only from the lens.

The copy of a painting, or the profile of an object, thus obtained, must of course be preserved in an obscure place, for all the attempts that have been made to prevent the uncoloured parts of the copy from being acted upon by light, have hitherto been unsuccessful. They have been covered with a thin coating of fine varnish; and they have been submitted to frequent washings; yet, even after this latter operation, it would seem that a sufficient quantity of the active matter will still adhere to the white parts of the surface, and cause them to become dark on exposure to the rays of the sun. From this circumstance, Davy thinks it probable that a portion of the metallic oxide abandons its acid, to enter into union with the animal or vegetable substance, so as to form with it an insoluble compound.

It will be remembered that Davy had made some early experiments on the collision of flint and steel *in vacuo*:* we find in the Royal Institution Journal a farther investigation of the subject; when he admits that, although sparks are not produced under these circumstances, yet that a faint light becomes visible. In many instances, he refers the phenomenon to electricity excited by friction, more especially in the instances of glass, quartz, sugar, &c. which give out light when rubbed. In other cases, he considers it probable that a species of phosphorescence may be occasioned by the heat; and he thinks that there may occasionally take place an actual ignition of abraded particles, in consequence of their imperfect conducting power; a supposition which he thinks receives strong support from an experiment of Mr. Wedgwood, who found that a piece of window-glass, when brought into contact with a revolving wheel of grit, became red hot at its point of friction, and gave off luminous particles that were capable of inflaming gunpowder and hydrogen gas.

We shall also find in this volume an account of some observations which he made upon the motions of small pieces of *acetate of potash*, during their

* See page 47.

solution, upon the surface of water. After the interesting and extraordinary observations of Mr. Brown, every phenomenon of this kind is calculated to excite attention.

Davy states that the fragments were agitated by very singular motions during the time of their solution, sometimes revolving for a second or two, and then moving rapidly backwards and forwards in various directions. He considers the phenomenon as evidently connected with the rapid process of solution, since the motions became weaker as the point of saturation approached. The thinnest film of oil, or of ether, wholly destroyed the effect. Those pieces which were most irregular in their forms underwent, by far, the most rapid motions; from which, he thinks, it would appear, that the phenomenon was in some measure owing to changes in the centre of gravity of the particles during their solution. The projectile motions, however, would seem to depend upon the continual descent of a current of the saline solution from the agitated particle, in consequence of which, the surrounding water would press upon different parts of it with different degrees of force. Besides which, an increase of temperature, which was found to accompany the solution of the salt, might in a degree modify the effect.

His first communication to the Royal Society was entitled, "An Account of some Galvanic Combinations, formed by an arrangement of single metallic plates and fluids, analogous to the Galvanic Apparatus of M. Volta."

It was read on the 18th of June 1801, and will be examined in a future part of these memoirs.

The certificate, recommending him as a candidate for the honour of a seat in the Royal Society, was read for the first time on the 21st of April 1803; and having been duly suspended in the meeting room, during ten sittings of the Society, according to the statute, he was put to the ballot, and elected on the 17th of November in the same year.

As every circumstance connected with the progress of Davy will be hereafter viewed with considerable interest, I shall here introduce the form of the certificate, and record the names of those Fellows who sanctioned it by their signatures.

"Humphry Davy, Esq. Professor of Chemistry in the Royal Institution of Great Britain, a gentleman of very considerable scientific knowledge, and author of a paper in the Philosophical Transactions, being desirous of becoming a Fellow of the Royal Society, we the undersigned do from our personal knowledge recommend him as deserving that honour, and as likely to prove an useful and valuable member."

(Signed)	Morton	W. G. Jordan,
	R. J. Sullivan,	John Walker,
	Kinnaird,	Richard Chenevix,
	Charles Hatchett,	Alexander Crichton,
	Thomas Young,	Henry C. Englefield,
	Webb Seymour,	Charles Wilkins,
	W. G. Maton,	Giffin Wilson,
	Thomas Rackett,	Gilbert Blane,
	James Edward Smith,	Edward Forster.

On the 7th of July, in the same year, he was elected an Honorary Member of the Dublin Society, having been proposed from the chair by the Vice-President, General Vallancey.

It has been stated that, shortly after Davy's arrival at the Institution, the Managers, being anxious to encourage all investigations of a practical tendency, directed him to deliver a series of lectures on the art of tanning. With this view, he entered into a scientific examination of the subject, in which he was encouraged by Sir Joseph Banks, the liberal patron and promoter of all useful knowledge, who supplied him with various materials for experiment.

The subject had recently attracted considerable attention, both at home and abroad, but much still remained to be effected; and Davy succeeded in adding many important facts to the general store.

In the Royal Institution Journal already noticed, we find several communications from him, under the titles of "Observations on different methods of obtaining Gallic Acid." "On the processes of Tanning," &c. All the new facts however, discovered in the course of his experiments, were embodied in a long and elaborate memoir, which was read before the Royal Society on the 24th of February 1803, and published in the Philosophical Transactions for that year. It was entitled "An Account of some Experiments and Observations on the constituent parts of certain astringent Vegetables, and on their operation in Tanning. By Humphry Davy, Professor of Chemistry in the Royal Institution. Communicated by the Right Honourable Sir Joseph Banks, P. R. S."

Although Seguin and Proust had already examined many of the properties of that vegetable principle, to which the name of *tannin* had been given, yet its affinities had been but little examined; and the manner in which its action upon animal matters may be modified by combination with other substances, had been still less considered.

His principal design in this enquiry was to elucidate the practical part of the art of tanning skins, so as to form leather; but in pursuing this object, he was necessarily led into chemical investigations connected with the analysis of the various bodies containing the tanning principle, and the peculiar properties and value of each.

The vegetable principles that had been regarded as more usually present in astringent infusions, are *tannin*, *gallic acid*, and *extractive matter*. In attempting to ascertain the relative proportions of *tannin* contained in different infusions, Davy was led, after various trials, to prefer the generally received method of precipitating by means of *gelatine* procured from isinglass. In using this test, however, he discovered that several precautions were necessary;—that the solution should be quite fresh,—that it should be as much saturated as may be compatible with its fluidity,—and that the precipitate obtained should be reduced to a uniform degree of dryness.

It is evident that if the quantity of gelatine in the solution, employed as the precipitant, be known, it will only be necessary to ascertain the weight of the precipitate produced by it, in order to learn the absolute proportion of tannin present in any specimen.

He next directed his attention to the discovery of some method by which the *gallic acid* might be separated from *extractive matter*, in cases where they exist in combination, but the enquiry was not successful; for, as he observes, it is difficult to render the *extractive* insoluble, so as to separate it, without at the same time decomposing the gallic acid. It is true that æther will dissolve the latter, without exerting much action upon the former; but then, he adds, whenever the gallic acid is in large quantities, this method will fail, "in consequence of that *affinity* which is connected with mass." Here then he adopts that celebrated theory of Berthollet,* which he afterwards so vigorously and successfully attacked.†

* Récherches sur les Lois de l'Affinité.—Mém. de l'Institut National, Tome III. p. 5.

† The masterly manner in which he combated the successive arguments of Berthollet upon this question is admirable. In the first place, he attacked the theory upon general principles, and then exposed the fallacy of the several experiments adduced in its support. "Were the proposition correct, that *in all cases of decomposition in which two bodies act upon a third, that third is divided between them in proportion to their relative affinities, and their quantities of matter*, it is quite evident

As general tests of the respective quantities of these two principles (gallic acid and extractive matter), he employed the solutions of the salts of alumina and those of the peroxidated salts of iron. The former of these precipitates *extractive*, without materially acting upon *gallic acid*, which is thrown down by the latter; the greatest care, however, must be taken not to add the iron in excess, as in that case the black precipitate formed will be redissolved, and an olive-coloured and clear fluid be only obtained.

He details the results of a number of experiments made upon galls, and ascertains the relative proportions of their several elements; and he proves that tannin may exist in such a state of combination in different substances as to elude the test of gelatine; in which case, to detect its presence, it is necessary to have recourse to the action of the diluted acids.

Sir Joseph Banks had concluded, from the sensible properties of *catechu*,* or *terra Japonica*, that it was rich in tannin: Davy confirmed this opinion by experiment. The leather tanned by it appeared to possess the same qualities as when tanned in the usual manner; and although this substance contains a small portion of extractive matter, yet the increase of weight of the skin was rather less than when solutions of galls were used.

In examining different barks, he was not able to procure from them any free gallic acid, but their infusions gave, on evaporation, tannin and extractive. The greater number of his experiments were made on the barks of the oak, the Leicester willow, the Spanish chestnut, the elm, and the common willow. The largest quantity of tannin he found to be contained in the interior, or white cortical layers; and the largest quantity of extractive matter in the

that there could be scarcely any definite proportions: a salt crystallizing in a strong alkaline solution would be strongly alkaline; in a weak one less alkaline; and in an acid solution it would be acid." With regard to glasses and alloys, adduced by M. Berthollet as compounds of indefinite proportions, Davy answers—"It is not easy to prove, in such cases, that the elements are chemically combined, for the points of fusion of alkali, glass, and certain metallic oxides, are so near to each other, that transparent mixtures of them may be formed." The experiment upon which M. Berthollet laid great stress, viz. that a large quantity of potash will separate a small quantity of sulphuric acid from sulphate of baryta, Davy invalidates in a most complete manner. He says—"This experiment was made in contact with the atmosphere, in which carbonic acid is always present, and carbonate of potash and sulphate of baryta mutually decompose each other."

* Catechu is an extract obtained from the wood of a species of the *Mimosa* that grows in India, by boiling and subsequent evaporation. It is of two kinds, one from Bengal, the other from Bombay. The former contains rather less, the latter rather more than half its weight of tannin. The remainder in both cases is a peculiar extractive matter mixed with mucilage.—P.

exterior layers ; the epidermis, or rough outward bark, did not contain either the one or the other.

From his general observations he is inclined to suppose that, in all the astringent vegetables, the tannin is of the same species, and that all the differences attributed to it depend upon its state of combination with other principles.

In applying the results of his experiments to the theory of tanning, he considers the process as simply depending upon the union of the tannin with the matter of the skin, in such a manner as to form with it an insoluble compound. Gallic acid, he feels assured, does not produce any notable effects in the process ; but he thinks that the quality of the leather depends, in some degree, upon the quantity of extractive matter it may imbibe.

Skin, combined with extractive matter only, would be increased in weight, become coloured, and be extremely flexible, but it would not be insoluble in water ; and were it combined with tannin alone, it would be heavier and less supple than when both these principles enter into the compound.

He examines with great acuteness and precision some of the more popular opinions entertained by tanners, and brings his science to bear very satisfactorily upon several of their processes.

The grand secret, on which the profit of the trade mainly depends, is to give the hides the greatest increase of weight in the least possible time. To effect this various schemes have been proposed, many of which, from the ignorance of the operators, instead of promoting have defeated the object. Different *menstrua* have been suggested for expediting the process, and amongst them lime-water and the solutions of pearl-ash ; but, as he has clearly shown, these two substances form compounds with tannin which are not decomposable by gelatine ; whence it follows that their effects must be pernicious ; and there is very little reason to suppose that any bodies will be found which, at the same time that they increase the solubility of tannin in water, will not likewise diminish its attraction for skin.

His experiments having proved that the saturated infusions of astringent barks contain much less extractive matter, in proportion to their tannin, than those which are weaker, it follows, that by quickly tanning the skin we render the leather less durable. These observations shew that there is some foundation for the vulgar opinion of workmen, concerning what is technically called the *feeding* of leather in the slow method of tanning.

Such is an outline of this interesting paper, in which the author has displayed the talent so characteristic of his mind, that of bringing science and art into useful alliance with each other. It forms, at this day, the guide of the tanner; and those who previously carried on the process by a routine of operations, of which they knew not the reasons, are now capable of modifying it, without the risk of spoiling the result. Many of those expedients which have been brought forward as novelties, in later years, may be found in this paper; or, at least, have arisen out of the principles disclosed during his investigations.

It has been stated that, shortly after Davy's successful *debut* as a lecturer, his manners underwent a change, and that, to the regret of his friends, he lost much of his native simplicity. On the 5th of February 1802, he had dined with Sir Harry Englefield at his house at Blackheath; and eighteen years afterwards, the worthy Baronet alluded to his interesting demeanour upon that occasion in terms sufficiently expressive of his feelings—"It was the last flash of expiring Nature." It was natural that his best friends, on perceiving this change of manner, should entertain some apprehensions as to the deeper qualities of his heart. From the tone of the following letter, it may be presumed that Mr. Poole, to whom it is addressed, had expressed some anxiety upon this point.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, London, May 1, 1803.

Have you no thoughts of coming to London? I have always recollected the short periods that you have spent in town, with a kind of mixed feeling of pleasure and regret.

In the bustling activity occasioned in cities by the action and reaction of diversified talents, occupations, and passions, our existence is, as it were, broken into fragments, and with you I have always wished for unbroken intercourse and continuous feeling.

* * * * *

* * * * *

Be not alarmed, my dear friend, as to the effect of worldly society on my mind. The age of danger has passed away. There are in the intellectual being of all men, permanent elements, certain habits and passions that cannot change. I am a lover of Nature, with an ungratified imagination. I shall continue to search for untasted charms,—for hidden beauties.

My *real*, my *waking* existence is amongst the objects of scientific research: common amusements and enjoyments are necessary to me only as dreams, to interrupt the flow of thoughts too nearly analogous to enlighten and to vivify.

Coleridge has left London for Keswick; during his stay in town, I saw him seldomer than usual; when I did see him, it was generally in the midst of large companies, where he is the image of power and activity. His eloquence is unimpaired; perhaps it is softer and stronger. His will is probably less than ever commensurate with his ability. Brilliant images of greatness float upon his mind; like the images of the morning clouds upon the waters, their forms are changed by the motion of the waves, they are agitated by every breeze, and modified by every sunbeam. He talked in the course of one hour, of beginning three works, and he recited the poem of Christobel unfinished, and as I had before heard it. What talent does he not waste in forming visions, sublime, but unconnected with the real world! I have looked to his efforts, as to the efforts of a creating being; but as yet, he has not even laid the foundation for the new world of intellectual forms.

When my agricultural lectures are finished, I propose to visit Paris, and perhaps Geneva. How I regret that circumstances had not enabled us to make the same tour at the same time. I think, at all events, I shall see you before the Autumn, on your own lands, amidst your own images and creations.

Your affectionate friend,
HUMPHRY DAVY.

From the above letter we learn that Davy, at this period, proposed delivering some lectures on the Chemistry of Agriculture. From the memorandums of my late friend, Mr. Arthur Young, the celebrated Secretary to the Board of Agriculture, I have succeeded, through the kindness of his daughter, in procuring the following extracts; the only source from which I have been able to obtain any correct information upon this point in his scientific life.—"May 15th, 1803. *Mem.* Two lectures by Mr. Davy have taken place, and been very well attended; they intend retaining him by a salary of a hundred pounds a year,—a very good plan."

Amongst the pamphlets at Bradfield Hall is a small quarto of fourteen pages, entitled, "Outlines of a Course of Lectures on the Chemistry of Agriculture, to be delivered before the Board of Agriculture, 1803." It was evidently only printed for private circulation amongst the members. At the same time, he printed a small pamphlet, containing an explanation of the terms used in chemistry, for the instruction of those amongst his audience who had not particularly directed their attention to the science.

The first lecture was delivered on Tuesday, May the 10th, at twelve at noon, and five others on the succeeding Tuesdays and Fridays.

In an address to the Board of Agriculture by Sir John Sinclair, delivered in April 1806, in reviewing the various objects to which the attention of the Board had been directed, he thus alludes to the subject—"In the year 1802, when my Lord Carrington was in the chair, the Board resolved to direct the attention of a celebrated lecturer, Mr. Davy, to agricultural subjects; and in the following year, during the Presidency of Lord Sheffield, he first delivered to the members of this Institution, a course of lectures on the Chemistry of Agriculture. The plan has succeeded to the extent which might have been expected from the abilities of the gentleman engaged to carry it into effect. The lectures have hitherto been exclusively addressed to the Members of the Board; but to such a degree of perfection have they arrived, that it is well worthy of consideration, whether they ought not to be given to a larger audience. If such an idea met with the approbation of the Board, a hall might be procured for that purpose, or a special course of lectures read in this room exclusively for strangers."

Davy would appear to have been very early impressed with the importance of chemistry, in its various applications to Agriculture. Allusions are constantly made to it in his letters; and at the conclusion of his "Researches," he glances at this department of the chemistry of vegetation, and observes that, "although it is immediately connected with the art upon which we depend for subsistence, it has been but little investigated."

In his introductory lecture of 1802, he speaks more forcibly upon the subject.

"Agriculture, to which we owe our means of subsistence, is an art intimately connected with chemical science; for, although the common soil of the earth will produce vegetable food, yet it can only be made to produce it in the greatest quantity, and of the best quality, by methods of cultivation dependent upon scientific principles.

"The knowledge of the composition of soils, of the food of vegetables, of the modes in which their products must be treated, so as to become fit for the nourishment of animals, is essential to the cultivator of land; and his exertions are profitable and useful to society, in proportion as he is more of a chemical professor; since indeed the truth has been understood, and since the importance of agriculture has been generally felt, the character of the agriculturist has become more dignified, and more refined;—no longer a mere machine of labour, he has learned to think, and to reason. He is aware of his usefulness to his fellow men, and he is become, at once, the friend of nature, and the friend of society."

His appointment, as chemical professor to the Board of Agriculture, was accompanied with the obligation of reading lectures before its members; which he continued to deliver every successive season for ten years, modifying and extending their views, from time to time, in such a manner as the progress of chemical discovery might render necessary.

These discourses were collated, and published in the year 1813, at the request of the President and members of the Board, and they form the only systematic work we, at present, possess on the subject. Its views, however, are too generally interesting to be briefly dismissed; I shall therefore enter more fully into their merits in a more advanced part of these memoirs.

His connexion with the Board necessarily brought him in contact with the practical agriculturists and capitalists of the day, with many of whom he formed friendships which lasted through life. With Mr. Coke of Holkham he became well acquainted, and generally formed one of the party at his annual sheep-shearing.* He was also a frequent visitor at Woburn, and received from the Duke the means by which he was enabled to submit to the test of practice various theories which his science had suggested.

In a letter to Mr. Gilbert, dated October 1803, he says, "I have just quitted the coast of Sussex, where I have spent the last three weeks with Lord Sheffield, the worthy biographer of Gibbon" In fact, there was not a nobleman,

* In the 40th volume of the "Annals of Agriculture," an account is given of the Holkham sheep-shearing for 1803, and in the list of the company is the name of "Mr. Professor Davy." At the meeting of 1808, he was also present, and is mentioned as the great chemist, whose discoveries will immortalize his name. Mr. Coke, in the course of his speech after dinner, alluding to the question of long and short dung, said, "It is the opinion of a friend of mine, who sits near me, Professor Davy, and upon whose judgment, on account of his extensive chemical as well as other scientific knowledge, I place the highest reliance, that the manure carried immediately on the field, without being disturbed, will have a greater effect in exciting rapid vegetation, and in encouraging the growth of the turnip plant, than when applied in the ordinary manner; for, under such circumstances, it will

distinguished for intellectual superiority, who did not feel a pride in receiving him as a guest; and he passed his vacations in the society of those exalted persons who, in possessing rank, fortune, and talents, felt that they only held such gifts from Providence, in trust for the welfare of their fellow countrymen.

We can scarcely picture to ourselves a being upon whom fortune ever showered more favours than upon Davy, during this golden period of his career. Independent in an honourable competence, the product of his genius and industry; resident in the centre of all scientific information and intelligence, every avenue of knowledge, and every mode of observation open to his unwearied intellect, he must have experienced a satisfaction which few philosophers have ever before felt, the power of pursuing experimental research to any extent, and of commanding the immediate possession of all the means it might require, without the least regard either to cost or labour. What a contrast does this picture afford to that which has been too faithfully represented as the more usual fate of the philosopher and man of letters, and which exhibits little more than the unavailing struggles of genius against penury! Instead of a life consumed in fruitless expectation of patronage and reward, we behold Davy, in the full bloom of reputation, courted by all whom rank, talent, or station, had rendered conspicuous.

His life flowed on like a pure stream, under a sky of perpetual sunshine, —not a gust ruffled its surface, not a cloud obscured its brightness. In the morning, he was the sage interpreter of Nature's laws; in the evening, he sparkled in the galaxy of fashion; and not the least extraordinary point in the character of this great man, was the facility with which he could cast aside the cares of study, and enter into the trifling amusements of society.—"*Ne otium quidem otiosum*," was the exclamation of Cicero, and it will generally apply to the leisure of men actively engaged in the pursuits of science; but Davy, in closing the door of his laboratory, opened the temple of pleasure. When not otherwise engaged, his custom was to play at billiards, frequent the theatre, or read

not only be more moist and alkaline, but it will be protected from a loss of substance, amounting very nearly to one-third of its original bulk." Davy afterwards, in company with the Duke of Bedford, Lord William Russel, Lord Thanet, Sir Joseph Banks, and other agriculturists, inspected several farms. In 1812, his health was drunk at the Woburn sheep-shearing by the Duke of Bedford; and in the following festival it was proposed by Lord Hardwicke.

In the print of the "Woburn Sheep-shearing," published by Garrard in 1811, No. 75 represents Davy; he is standing, in a listening attitude, behind Mr. Coke, who is conversing with Sir Joseph Banks, Sir John Sinclair, and Mr. Arthur Young.

the last new novel. In ordinary cases, the genius of evening dissipation is an arrant Penelope; but Davy, on returning to his morning labours, never found that the thread had been unspun during the interruption.

The following anecdote is well calculated to illustrate that versatility of talent of which I have frequently spoken, as well as the power he possessed of abstracting himself, without detriment, from the most elaborate investigations. A friend of the late Mr. Tobin called upon him at the Institution, and found him deeply engaged in the laboratory; their conversation turned upon the "Honey Moon," which was to be brought out on the following evening.* No sooner had Davy heard that, although pressing applications had been made to several of the poets of the day, a Prologue had not yet been written, than he instantly quitted the laboratory, and in two hours produced that which was recited on the occasion by Mr. Bartley, and printed in the first edition of the comedy. I insert it in this place.

No uniformity in life is found:—
In ev'ry scene varieties abound;
And inconsistency still marks the plan
Of that immortal noble being, Man.
As changeful as the April's morning skies,
His feeling and his sentiments arise;
And nature to his wond'rous frame has given
The mingled elements of earth and heaven.
In diff'rent climes and ages, still we find
The same events for diff'rent ends design'd:
And the same passion diff'rent minds can move
To thoughts of sadness or to acts of love.
Hence Genius draws his novel copious store;
And hence the new creations we adore:
And hence the scenic art's undying skill
Submits our feeling to its potent will;
From common accidents and common themes
Awakens rapture and poetic dreams;
And, in the trodden path of life, pursues
Some object cloth'd in Fancy's loveliest hues—

* The Honey Moon was produced at Drury Lane, on Thursday, the 30th of January, 1805.

To strengthen nature, or to chasten art,
To mend the manners or exalt the heart.
So thought the man whom you must judge to-night;
And as he thought, he boldly dared to write.
Not new the subject of his first-born rhyme;
But one adorn'd by bards of elder time;—
Bards with the grandest sentiments inspired—
Bards that in rapture he has still admired;
And tried to imitate, with ardour warm,
And catch the spirit of their pow'rful charm.
With loftiest zeal and anxious hope he sought
To bring to modern times their strength of thought;
And, in their glowing colours, to display
The follies and the virtues of the day.
Whether his talents have his wish belied,
Your judgment and your candour must decide.
He, though your loftiest plaudits you should raise—
He cannot thank you for the meed of praise.
Rapture he cannot feel, nor fear, nor shame;
Connected with his love of earthly fame,
He is no more.—Yet may his memory live
In all the bloom that early worth can give!
Should you applaud, 'twould check the flowing tear
Of those to whom his name and hopes are dear.
But should you an unfinish'd structure find,
As in its first and rudest forms design'd,
As yet not perfect from the glowing mind,
Then with a gentle voice your censure spread,
And spare the living—spare the sacred Dead!

Davy would appear to have frequently amused himself with writing sonnets, and inclosing them in letters to his several friends; the following letter will also show that he was ambitious of being considered a poet.

TO SAMUEL PURKIS, ESQ.

MY DEAR PURKIS,

I INCLOSE the little poem,* on which your praise has stamped a higher value, I fear, than it deserves.

If I thought that people in general would think as favourably of my poetical productions, I would write more verses, and would write them with more care; but I fear you are partial: I am very glad, however, that you like the little song; at some future period I will send you another.

With kind remembrances,

Unalterably your sincere friend,

H. DAVY.

On examining the laboratory notes made at this period, many of which, however, are nearly illegible from blots of ink and stains of acid, it would appear that his researches into the composition of mineral bodies were most extensive, and that he obtained many new results, of which he does not seem to have availed himself in any of his subsequent papers. To borrow a metaphor from his favourite amusement, he treated such results as small fry, which he returned to their native element to grow bigger, or to be again caught by some less aspiring brother of the angle.

Had Davy, at this period of his life, been anxious to obtain wealth,† such was his chemical reputation, and such the value attached to his judgment, that, by lending his assistance to manufacturers and projectors, he might easily have realized it; but his aspirations were of a nobler kind — SCIENTIFIC GLORY was the grand object for which his heart panted; by stopping to collect the golden apples, he might have lost the race.

* The subject was *"Julia's Eyes."*

† I am assured by one of his earliest friends that, at this period, he did not appear even to have an idea of the value of property. Any thing not immediately necessary to him he gave away, and never retained a book after he had read it.

CHAPTER V.

Sir Thomas Bernard allots Davy a piece of ground for Agricultural Experiments.—History of the Origin of the Royal Institution.—Its early labours. — Davy's Letters to Mr. Gilbert and to Mr. Poole.—Death of Mr. Gregory Watt.—Davy's passion for Fishing, with Anecdotes.—He makes a Tour in Ireland: his Letters on the subject.—His Paper on the Analysis of the Wavellite.—His Memoirs on a new method of analysing Minerals which contain a fixed Alkali.—Reflections on the discovery of Galvanic Electricity.

VERY shortly after Davy had arrived in London, he formed an intimate friendship with Mr. (afterwards Sir Thomas) Bernard; and no sooner had he directed his attention to the subject of Philosophical Agriculture, than the worthy Baronet allotted him a considerable piece of ground near his villa at Roehampton, where, under his sole direction, numerous experiments were tried, many of which proved highly successful, and afterwards served for the illustration of various subjects in his work on AGRICULTURAL CHEMISTRY.

Although devoted as Davy was to the pursuits of science, he entered warmly into all political plans for improving the condition of the people, and advancing the progress of civilization. "No one," says his friend Mr. Poole, "was less a sectarian, if I may use the word, in religion, politics, or in science. He regarded with benevolence the sincere convictions of any class on the subject of belief, however they might differ from his own. In politics, he was the ardent friend of rational liberty. He gloried in the institutions of his country, and was anxious to see them maintained in their purity by timely and temperate reform." Indeed, in carefully analysing his mind, and tracing its developement, it appears that benevolence was one of its leading elements; the form in which it displayed its energies varying with the varying conditions of intelligence. In boyish life, his imagination, acting upon his zeal for the welfare of his species, delighted, as we have seen, in the ideas of encountering dragons, and quelling the might of giants; but as fancy paled with the light of advancing years, and the judgment presented distincter appearances, the philanthropic antipathy which had been directed to those chimeras of the nursery, was transferred to the two great oppressions of society, and in Superstition he saw the dragons—in Despotism the giants that spread mischief and misery through the world.

Some of his early manuscripts are still in existence; and I shall here introduce a passage from one which has been lately transmitted to me by a gentleman resident in Penzance. The most trifling record becomes interesting when we can trace in it the germ of a particular opinion, or the first symptom of a quality which may afterwards have distinguished its possessor.

"Science is as yet in her infancy; but in her infancy she has done much for man. The discoveries hitherto so beneficial to mankind have been generally effected by the energies of individual minds:—what hopes may we not entertain of the rapid progress of the happiness of man when illumination shall become general—when the united powers of a number of scientific men shall be employed in discovery! Every thing seems to announce the rapid advance of this period of improvement. The time is approaching when despotism and superstition, those enormous chains that have so long enfettered mankind, shall be annihilated,—when liberated man shall display the mental energies for which he was created. At that period nations shall know that it is their interest to cultivate science, and that the benevolent philosophy is never separated from the happiness of mankind."

In his published writings we discover evidences of the same tendency; he suffers no opportunity to escape which can enable him to enforce his principle, and he extracts from the most common as well as from the least probable sources, comparisons and analogies for its illustration. The ingenuity with which this is accomplished often surprises and delights us; the effect upon the reader is frequently not unlike that occasioned by the flashes of wit, to which it surely must be closely allied, if wit be correctly defined by Johnson "a combination of dissimilar images, or the discovery of occult resemblances in things apparently unlike." Is not this opinion strikingly illustrated by the happy turn given to his observations "upon the process of obtaining nitrous oxide from nitre,"—when he says, "thus, if the hopes which these experiments induce us to indulge do not prove fallacious, a substance which has heretofore been almost exclusively appropriated to the destruction of mankind, may become, in the hands of philosophy, the means of producing health and pleasure!"

Mr. Poole, who watched the whole of his progress from obscurity to distinction, and enjoyed his friendship for nearly thirty years, says, "To be useful to science and mankind was, to use his favourite expression, the pursuit in which he gloried. He was enthusiastically attached to science, and to men of science; and his heart yearned to promote their interests."

That Davy, with a mind so constituted, should have formed a strong and ardent attachment to Sir Thomas Bernard, and that this friendship should have been reciprocally cultivated, cannot be a matter of surprise.

I am happy in this opportunity of paying a tribute of respect to the memory of this most excellent person, with whom I had the pleasure of being well acquainted. His life was one continued scheme of active benevolence; and he merits a particular notice in these memoirs, as being one of the principal founders and patrons of the Royal Institution. Actuated by that noble and rational ambition which makes private pursuits subservient to public good, he directed all the energies of his mind, the influence of his station, and the resources of his wealth, towards promoting societies and schemes for encouraging the virtues and industry, and for ameliorating the condition of the lower classes.

In the beginning of November 1796, in conjunction with the late Bishop of Durham, Mr. Wilberforce, and Mr. Elliot, he established the SOCIETY FOR BETTERING THE CONDITION OF THE POOR. As one of the primary objects of the original promoters of this society was the formation of an institution which might teach the application of science to the advancement of the arts of life, and to the increase of domestic comforts, a select committee was appointed from its body, in January 1799, for the purpose of conferring with Count Rumford on the means of carrying such a scheme into practical effect. This committee consisted of the Earl of Winchelsea, Mr. Wilberforce, Mr. Sullivan, the Bishop of Durham, Sir Thomas Bernard, and some other members of the society; and in a few weeks they completed the arrangements, circulated printed proposals, and collected the subscriptions, which gave birth to the ROYAL INSTITUTION OF GREAT BRITAIN, the future cradle of experimental science, and the destined scene of Davy's glory.

In addition to the general objects of promoting the arts and manufactures, and of advancing the taste and science of the country, its more immediate purpose was the improvement of the means of industry and domestic comfort among the poor.

That this benevolent design was constantly kept in sight may be shown by the several resolutions passed at the different meetings of the managers, especially at that held in March 1800; when it was resolved to appoint *fourteen* different committees, for the purpose of scientific investigation and improvement; amongst which were the following:—

"For the investigation into the processes of making bread, and into the methods of improving it.

"For enquiring into the art of preparing cheap and nutritious soups for feeding the poor.

"For improving the construction of cottages, and cottage fire-places; and for improving kitchen fire-places, and kitchen utensils.

"For ascertaining, by experiment, the effects of the various processes of cookery upon the food of cattle.

"For improving the construction of lime-kilns, and the composition of mortar and cements," &c. &c.

So that the foundation and original arrangements of the Royal Institution were not only calculated to extend the boundaries of science, but to increase its applications and to promote and improve those arts of life on which the subsistence of all, and the comfort and enjoyment of the great majority of mankind absolutely depend.

At this early period of its history, the Royal Institution presented a scene of the most animated bustle and exhilarating activity. Persons most distinguished in the various departments of science and art were to be seen zealously and liberally co-operating for the promotion and diffusion of public happiness, under the cheering beams of popular favour and exalted patronage. It was like 'a busy ant-hill in calm and sunshine.'

I shall only add, that Sir Thomas Bernard was the original promoter of the "School for the Indigent Blind," of an institution for the protection and instruction of "Climbing Boys," of a society for the relief of "Poor Neighbours in Distress," of the "Cancer Institution," and of the "London Fever Hospital."

The philanthropic Baronet was, moreover, the founder of the "British Institution," for promoting the Fine Arts in the United Kingdom; and he was also the originator of the "Alfred Club."

The vast range and practical utility of these exertions were duly appreciated by his contemporaries, who were ever ready to promote any scheme which had received the sanction of his patronage. It is an anecdote worthy of being preserved, that the late Sir Robert Peel called upon him one morning, and after a general conversation on the different philanthropic objects they had in view, said on leaving the room, he had to request Sir Thomas that he would dispose of something for him, in any manner he thought most serviceable, and laid on the table an enclosure. After he had left the house, Sir Thomas was greatly surprised, on opening it, to find a bank-note of a thousand pounds.

The active zeal of this worthy Baronet, like every other circumstance which exceeds the ordinary standard of our conduct, or becomes prominent from the rarity of its occurrence, called forth the wit as well as the admiration of his contemporaries. One of those modern travellers who delight in astonishing their auditors by incredible tales and marvellous anecdotes, happening to be in company with a noble lord as much distinguished for the playfulness of his wit as for the profundity of his learning, told the following improbable story: that, in a sequestered part of Italy, when pressed by hunger and fatigue, he sought refreshment and repose in a wild dwelling in the mountains, and was agreeably surprised at being offered a pie; but, horror of horrors! on examining its contents he found—a human finger!—"Nothing more probable, Sir," interrupted his Lordship, "and I well know the person to whom that finger belonged—to Sir Thomas Bernard, Sir, for he had a finger in every pie."

The following letters will be read in this place with interest.

TO DAVIES GIDDY, ESQ.

MY DEAR SIR,

I AM now on my way to Christchurch, in company with Mr. Bernard, who was the founder, and has been the great supporter of the Society for bettering the condition of the Poor.

In a conversation that has just passed between us, I mentioned the state of improvement of the Downs, between Helston and Marazion, in consequence of grants of small portions of land to miners and other tenants for cultivation, many of which have, I believe, been made by Lord Dunstanville. Mr. Bernard expressed a desire to know what the effect of this plan had been on the condition of the persons thus raised into "property-men."

He is accumulating facts as to the manner in which the poor have been most effectually benefited, and to assist his labour would be to assist a good and most important cause; perhaps, you will have the goodness to give me a statement on this subject, which of course shall be used as you may think proper. You may likewise have similar facts nearer home, on your own estates.

I am convinced that the effects of enabling the common labourer to acquire property must be striking, and must often have been an object of your contemplation.

In making any statement of these facts, you will probably think it right to mention some particular cases, with dates, names, and accounts of the quantities of lands, the nature of the improvements, &c.

In the reports of the "Society for bettering the condition of the Poor," there is one made on this minute plan of Lord Winchelsea's grants of land to cottagers, which conveys very full and useful information.

I trust to your kindness, and believe me,

Your obliged,

H. Davy.

The following letter was written by Davy after his return from an excursion to that beautiful district, the north-west of the county of Somerset.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, October, 1804.

I returned to town a little while ago, not sorry to see the great city of activity and life; not sorry to see it, though I had just spent two months in enjoying a scenery beautiful and, to me, new; in witnessing much hospitality and unadulterated manners, and in gaining much useful information.

Mr. Bernard is writing a history of the poor. I have lived much with him at Roehampton since my return, and he has read to me part of his work, which is popularly eloquent, very intelligent, and full of striking and important truths; but pray say nothing of this, for it is likely that it will appear without his name; the facts will be strong, and perhaps to some people offensive.

I have received a letter from Coleridge within the last three weeks: he writes from Malta in good spirits, and, as usual, from the depth of his Being.

God bless him!—He was intended for a great man; I hope and trust he will, at some period, appear as such.

I am working very hard at this moment, and I hope soon to send you some of the fruits of my labours. I am likewise devising some plans at our Institute, for the improvement of "this generation of vipers;" but, although I am so vain as to announce them, I will not be so tedious as to detail them.

In your answer, which I hope I shall soon receive, pray give me an account of the situation of "Poole's Marsh," with regard to the *Parrot*,* for I have mentioned the soil in a paper to the Board of Agriculture, which is now in the press.

I am, my dear Poole,

Your truly affectionate friend,

H. Davy.

In this year Davy was deprived of one of his earliest and most attached friends, after a lingering illness, during which his symptoms, by the alternations which characterise consumption, had inspired his friends with hope, only to chill them with despondency;—Gregory Watt terminated his earthly career.†

On the first impression which this melancholy event produced upon his feelings, Davy wrote a letter to his friend Clayfield, from which the following is an extract.

"I scarcely dare to write upon the subject—I would fain do what Hamlet does, when, in awe and horror at the ghost of his father, he attempts to call up the ludicrous feeling, but being unable to do so, he merely employs the words which are connected with it.—I would be gay, or I would write gaily, in alluding to the loss we have both sustained, but I feel that it is impossible. Poor Watt!—He ought not to have died. I could not persuade myself that he would die; and until the very moment when I was assured of his fate, I would not believe he was in any danger.

* He alludes to a rich piece of land near the river Parrot, a specimen of the soil of which Mr. Poole had sent him for analysis.

† Gregory Watt was one of those philosophers to whose memory justice has not awarded its due. He was a meteor, whose light no sooner flashed upon us than it expired. His paper upon the gradual refrigeration of Basalt, alone entitled him to a distinguished rank amongst experimentalists. It was read before the Royal Society in May, and he expired in the following October. I shall have occasion to refer hereafter to its merits.

" His letters to me, only three or four months ago, were full of spirit, and spoke not of any infirmity of body, but of an increased strength of mind. Why is this in the order of Nature, that there is such a difference in the duration and destruction of her works? If the mere stone decays, it is to produce a soil which is capable of nourishing the moss and the lichen; when the moss and the lichen die and decompose, they produce a mould which becomes the bed of life to grass, and to a more exalted species of vegetables. Vegetables are the food of animals,—the less perfect animals of the more perfect; but in man, the faculties and intellect are perfected,—he rises, exists for a little while in disease and misery, and then would seem to disappear, without an end, and without producing any effect.

" We are deceived, my dear Clayfield, if we suppose that the human being who has formed himself for action, but who has been unable to act, is lost in the mass of being; there is some arrangement of things which we can never comprehend, but in which his faculties will be applied.

" The caterpillar, in being converted into an inert scaly mass, does not appear to be fitting itself for an inhabitant of air, and can have no consciousness of the brilliancy of its future being. We are masters of the earth, but perhaps we are the slaves of some great and unknown beings. The fly that we crush with our finger, or feed with our viands, has no knowledge of man, and no consciousness of his superiority. We suppose that we are acquainted with matter, and with all its elements, and yet we cannot even guess at the cause of electricity, or explain the laws of the formation of the stones which fall from meteors. There may be beings, — thinking beings, near us, surrounding us, which we do not perceive, which we can never imagine. We know very little; but, in my opinion, we know enough to hope for the immortality, the *individual immortality of the better part of man.*

" I have been led into all this speculation, which you may well think wild, in reflecting upon the fate of Gregory! my feeling has given erring wings to my mind. He was a noble fellow, and would have been a great man.—Oh! there was no reason for his dying—he ought not to have died.

" Blessings wait on you, my good fellow! Pray remember me to Tobin, and, if you read this letter to him, protest, the moment he begins to argue against the immortality of man!

" I came yesterday from the borders of Dorsetshire, where I have been since Monday, seduced to travel by a friend. I was within sixty miles of you, and saw divers fair trout-streams; let the fish beware of me,—I shall be at them on Monday."

I have included this latter sentence in my extract, as being highly characteristic of the writer. His passion for angling betrayed itself upon all occasions; and the sport was alike his relief in toil, and his solace in sorrow. To his conversation, as well as to his letters, we may aptly apply the words of the Augustan poet:—

"Desinit in piscem——formosa superne."

Whenever I had the honour of dining at his table, the conversation, however it might have commenced, invariably ended on fishing; and when a brother of the angle happened to be present, you had the pleasure of hearing all his encounters with the finny tribe—how he had lured them by his treachery, and vanquished them by his perseverance. He would occasionally strike into a most eloquent and impassioned strain upon some subject which warmed his fancy; such, for example, as the beauties of mountain scenery; but before you could fully enjoy the prospect which his imagination had pictured, down he carried you into some sparkling stream, or rapid current, to flounder for the next half hour with a hooked salmon!

I remember witnessing, upon one of these occasions, a very amusing scene, which may be related as illustrative of some peculiarities of his temper. I believe all those who have accompanied Davy in his fishing excursions, will allow that no sportsman was ever more ambitious to appear skilful and lucky. Nothing irritated him so much as to find that his companions had caught more fish than himself; and if, during conversation, a brother fisherman surpassed him in the relation of his success, he betrayed similar impatience.

There happened to be present, on the occasion to which I allude, a skilful angler, and an enterprising chemist. The latter commenced on some subject connected with his favourite science, but Davy, who, generally speaking, disliked to make it a subject of conversation, suddenly turned to the angler, and related what he considered a very surprising instance of his success; his sporting friend, however, mortified him by the relation of a still more marvellous anecdote; upon which Davy as quickly returned to the chemist, who, in turn, again sent him back to the angler; and thus did he appear to endure the unhappy fate of the *flying fish*, who no sooner escapes from an enemy in the regions of air, than he is pursued by one equally rapacious in the waters.—But to return to the thread of our history.

In referring to the records of the Institution, it appears that in January 1805, Davy greatly enriched the cabinets of the Institution by a present of minerals. The following are the Minutes of the Committee upon this occasion:

"January 21, 1805.—Mr. Hatchett reported that, in pursuance of the request of the Managers, he had inspected the minerals presented to the Royal Institution by Mr. Davy, and that the aggregate value (including the duplicate specimens) appears to him to exceed one hundred guineas."

"January 28.—The Managers took into consideration Mr. Hatchett's report at the last meeting, and resolved that Mr. Davy is entitled to the thanks of the Managers, for having added so valuable a present to the collection of minerals belonging to the Institution."

On the 4th of February, it was Resolved—"That Mr. Davy be appointed Director of the Laboratory, at a salary of one hundred pounds a-year;" by which his annual income from the Institution was raised to four hundred pounds. At this period, he delivered a series of lectures on Geology, or on the chemical history of the earth; to which we find an allusion in the following letter.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, February, 1805.

I AM very much obliged to you for your last kind letter, and I thank you most sincerely for the exertion of your friendship at Bath. I thank you with very warm feelings.

I hope you will soon come to town; that you will stay a long time; and that we shall be very much together.

I paid your subscription to Arthur Young for the Smithfield Club. Pray, at all times, command me to do any thing I can for you in London:—you cannot teaze me; and though I am a very idle fellow, yet I can always work if the stimulus be the desire of serving such a friend as yourself.

I am giving my course of lectures on Geology to very crowded audiences. I take a great interest in the subject; and I hope the information given will be useful.

There has been no news lately from Coleridge; the last accounts state that he was well in the autumn, and in Sicily. On that poetic ground we may hope and trust that his genius will call forth some new creations, and that he may bring back to us some garlands of never-dying verse. I have written to urge him strongly to give a course of lectures on Poetry at the Royal Institution, where his feeling would strongly impress, and his eloquence greatly delight. I am, my dear Poole, most affectionately

Yours,

H. Davy.

On the 20th of May in this year, Mr. Hatchett reported to the Managers of the Institution—"that Mr. Davy proposed making a journey into Wales and Ireland this summer, having in view to collect specimens for enriching the mineralogical cabinets;" in consequence of which it was Resolved—"That the sum of one hundred pounds be entrusted to Mr. Davy to purchase minerals, and to defray the incidental charges; and that the boy of the Laboratory, William Reeve,* be ordered to attend him on his tour, and that the steward be directed to defray his expenses.

From the following letters it would appear, that, having accomplished his purpose of visiting Ireland, he made a rapid journey into Cornwall for the sake of seeing his mother and sisters.

TO DAVIES GIDDY, ESQ.

MY DEAR SIR, Okehampton, September 1805.

I am accompanying my friend Mr. Bernard in a tour through the West of England, and I hope we shall reach Penzance in two or three days.

Mr. Bernard wishes much for the honour of your acquaintance, and I trust you will permit me to have the pleasure of making you known to him. Much kindness and long knowledge of him, may have made me partial to that gentleman, and may perhaps influence me when I say that there is not a more patriotic, good, and public-spirited man in Great Britain.

I came from Ireland by the western road, about a fortnight ago. My expectations were fully satisfied with the appearances of the "Giant's Causeway." The arrangements of rocks of the Northern Cape of Ireland appear to me to present facts equally irreconcilable upon either the Plutonic or Neptunian theory, and I am convinced that general fanciful theories will lose ground in proportion as minute observations are multiplied.

The Irish are a noble race, degraded by slavery, and bearing the insignia of persecution, extreme savageness, or the lowest servility; yet they are inge-

* There are some circumstances of interest connected with the history of this young man. He possessed much chemical talent; but during his residence in Ireland he was converted to the Catholic religion, and is at this time a Catholic priest in some part of the Continent.

nious and active, and seem to me to possess all the elements of power and usefulness; but amongst the lower orders there is a most unfortunate equality, destructive of all great and efficient exertion; and amongst the higher classes the greatest degree of activity is awakened only by the desire of imitating the English, and that not so much in their virtues and talents as in their luxuries and follies.

I hear from all quarters of the good effects of your late exertions in Parliament; may your efforts tend to establish the reign of good sense and pure philosophy, in a place where they have been too often found to yield to empty sounds!

Yours, &c.

H. Davy.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, London, October 9, 1805.

I made a very rapid journey to Cornwall with Mr. Bernard, merely for the sake of shewing him the country, and for the purpose of spending a week with my mother and sisters.

We made an effort to come to you at Nether Stowey, but the people at Bridgewater would not take us round, through Stowey, to Taunton, without four horses; and at all events we could only have spent two or three hours with you; and it is difficult to say whether the pleasure of meeting, or the regret at parting so soon, would have been the greatest. I long very much for the intercourse of a week with you. I have very much to say about Ireland. It is an island which might be made a new and a great country. It now boasts a fertile soil, an ingenious and robust peasantry, and a rich aristocracy; but the bane of the nation is the equality of poverty amongst the lower orders. All are slaves without the probability of becoming free; they are in the state of equality which the *Sans-culottes* wished for in France; and until emulation and riches, and the love of clothes and neat houses, are introduced amongst them, there will be no permanent improvement.

Changes in political institutions can at first do little towards serving them. It must be by altering their habits, by diffusing manufactories, by destroying *middle-men*, by dividing farms,* and by promoting industry by

* He means that the *middle-men* being discontinued, their large allotments should be divided into farms of convenient extent, the occupiers of which should rent immediately from the owners of the soil.

making the pay proportioned to the work. But I ought not to attempt to say any thing on the subject when my limits are so narrow; I hope soon to converse with you about it.

I found much to interest me in geology in Ireland, and I have brought away a great deal of information, and many specimens.

I shall now be in London till Christmas, with the exception of next week, which I am obliged to pass in Bedfordshire.

I am, my dear Poole,
Most affectionately your's,
H. Davy.

After the Giant's Causeway, the scenery which called forth Davy's greatest admiration in Ireland was that of Fair-Head. To an enthusiastic lover of the wild and sublime features of Nature, an object of greater interest could scarcely be presented than a vast promontory, the summit of which rises five hundred feet above the sea, and at whose base lies a waste of rude and gigantic columns, swept by the hand of time from the mountain to which they formerly belonged.

The following fragment, written by Davy at the time, has been placed in my hands by Mr. Greenough.

"——— but chiefly thee, Fair-Head!
Unrivall'd in thy form and majesty!
For on thy loftiest summit I have walk'd
In the bright sunshine, while beneath thee roll'd
The clouds in purest splendour, hiding now
The ocean and his islands—parting now
As if reluctantly: whilst full in view
The blue tide wildly roll'd, skirted with foam,
And bounded by the green and smiling land,
The dim pale mountains, and the purple sky.
Majestic cliff! thou birth of unknown time,
Long had the billows beat thee, long the waves
Rush'd o'er thy hollow'd rocks, ere life adorn'd
Thy broken surface, ere the yellow moss
Had tinted thee, or the mild dews of Heaven

Clothed thee with verdure, or the eagles made
Thy cave their aery: so in after time
Long shalt thou rest unalter'd mid the wreck
Of all the mightiness of human works;
For not the lightning nor the whirwind's force,
Nor all the waves of ocean, shall prevail
Against thy giant strength—and thou shalt stand
Till the Almighty voice which bade thee rise
Shall bid thee fall."

Amongst Davy's letters to Mr. Gilbert, in the years 1804 and 1805, I find several upon the subject of the elastic force of steam, at different temperatures, with reference to Mr. Trevitheck's improvements in the steam-engine; in one of which he says, "I shall be extremely happy to hear of the results of your enquiries, and I hope you will not confine them to your friends, but make them public. Whenever speculative leads to practical discovery, it ought to be well remembered, and generally known: one of the most common arguments against the philosophical exercise of the understanding is, *cui bono?* It is an absurd argument, and every fact against it ought to be carefully registered. Trevitheck's engine will not be forgotten, but it ought to be known and remembered that your reasonings and mathematical enquiries led to the discovery."

On the 28th of February 1805, was read before the Royal Society, and published in the Transactions of that year, a paper entitled, "An Account of some analytical Experiments on a mineral production from Devonshire; consisting principally of Alumina and Water, by Humphry Davy, &c."

This mineral was first discovered by Dr. Wavel in small veins and cavities, in a tender argillaceous slate, near Barnstaple in Devonshire. At first it was considered as a species of *Zeolite*, until Mr. Hatchett concluded, from its geological position, that it did not belong to that family of minerals; Dr. Babington subsequently suspected from its physical characters, and from some of its habitudes with acids, that it was a mineral not before described, and accordingly placed a quantity of it in Davy's hands for analysis; who, on finding in its composition little more than clay and water, proposed to change the name of *Wavellite* for that of *Hydrargyllite*, as better expressive of its chemical nature. He however, at the same time, alludes to traces of an acid which he was unable to identify.

In a letter to Mr. Nicholson, dated Killarney, June 15, 1806, and which was afterwards published in his Journal, Davy refers to this fact in the following manner:—

DEAR SIR,

I SHALL feel much obliged to you to mention that I have found the acid which exists in minute quantities in Wavellite to be the *Fluoric acid,* in such a peculiar state of combination as not to be rendered sensible by sulphuric acid.

I am, &c.

H. DAVY.

My late friend the Reverend William Gregor, having found the Wavellite at Stenna Gwynn, in Cornwall, submitted it to experiment, and the result certainly established the conclusion of the presence of fluoric acid, though not rendered apparent by the usual tests. The facts were transmitted to the Royal Society, and published in a paper entitled, "On a mineral Substance, formerly supposed to be Zeolite; by the Reverend William Gregor."

The subsequent experiments of Berzelius, however, cleared away the obscurity in which the subject was still involved. He shewed that this mineral not only contained in its composition a small portion of the *neutral fluate of alumina,* but he demonstrated the presence of a *sub-phosphate* of that earth, to no inconsiderable an amount. Much has been said of the error committed on this occasion by Davy, in overlooking thirty-three per cent. of phosphoric acid; but the *phosphate of alumina* is a body that might very easily have escaped notice at a period when mineral analysis was in a far less advanced state than it is at present.

On the 16th of May 1805, Davy communicated to the Royal Society a paper, "On the method of analysing Stones containing a fixed alkali, by means of the boracic acid." This method was founded upon two important facts; first, on the considerable attraction of boracic acid for the different simple earths at the heat of ignition; and, secondly, on the facility with which the compounds so formed are decomposed by the mineral acids. The processes are extremely simple, and the method must be considered as having advanced the art of mineral analysis.

In 1806, Mr. Poole, having consulted Davy on the subject of a Mine occurring near Nether Stowy, received from him the following letter, which is interesting from the political opinions it displays.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE,

WHAT you have written concerning the indifference of men with regard to the interest of the species in future ages, is perfectly just and philosophical; but the greatest misfortune is, that men do not attend even to their own interest, and to the interest of their own age in public matters. They think in moments, instead of thinking, as they ought to do, in years; and they are guided by expediency rather than by reason. The true political maxim is, that the good of the whole community is the good of every individual; but how few statesmen have ever been guided by this principle! In almost all governments, the plan has been to sacrifice one part of the community to other parts;—sometimes the people to the aristocracy, at other times the aristocracy to the people;—sometimes the Colonies to the Mother-country, and at other times the Mother-country to the Colonies. A generous enlightened policy has never existed in Europe, since the days of Alfred, and what has been called "the balance of power"—the support of civilization,—has been produced only by jealousy, envy, bitterness, contest, and eternal war, either carried on by pens or cannon, destroying men morally and physically! But if I proceed in vague political declamation, I shall have no room left for the main object of my letter—your Mine. I wish it had been in my power to write decidedly on the subject; but your county is a peculiar one: such indications would be highly favourable in Cornwall; but in a *shell-limestone* of late formation, there have as yet been no instances of great copper mines. I hope, however, that your mine will produce a rich store of *facts.*

Miners from Alston Moor, or from Derbyshire, would understand your country better than Cornish miners, for the Cornish shifts are wholly different from yours. It would be well for you to have some workmen at least from the North, as they are well acquainted with *shell-limestone.*

The Ecton copper mine in Staffordshire is in this rock; it would be right for you to get a plan and a history of that mine, which might possibly assist your views.

Had I been rich, I would adventure; but I am just going to embark with all the little money I have been able to save for a scientific expedition to Norway, Lapland, and Sweden. In all climes, I shall be your warm and

Sincere friend,

H. DAVY.

On the death of Dr. Edward Whitaker Gray, Secretary of the Royal Society, Davy was elected into that office, at an extraordinary meeting of the Society, on the 22nd of January 1807; and at the same time he was elected a member of the council.

We are now advancing to that brilliant period in the history of our philosopher, at which he effected those grand discoveries in science, which will transmit his name to posterity, associated with those of Newton, Bacon, Locke, and the great master-spirits of every age and country. I speak of his developement of the Laws of Voltaic Electricity.

I approach the subject with that diffidence which the contemplation of mighty achievements must ever produce in the mind of the historian, when he compares the extent and magnitude of his subject with the limited and feeble powers which are to describe them.

As the advantages afforded by the history of any great discovery consist as much in exhibiting, step by step, the intellectual operations by which it was accomplished, as in detailing its nature and applications, or in examining its relations with previously established truths; so shall I be unable to preserve a chronological succession in the examination of those several memoirs which he presented to the Royal Society, without breaking asunder that fine intellectual thread, by which his mind was conducted through the intricate paths of nature from known to unknown phenomena. For this reason, although I announced, according to the date of its publication, the subject of his first paper on electricity, I deferred entering upon its examination, until I might be able to bring into one uninterrupted view the whole enquiry, in all its branches and bearings.

It is impossible to enter upon the subject of galvanism, or Voltaic electricity, without recurring to the circumstance which first betrayed the existence of such an energy in nature, and to the sanguine expectations which the discovery so naturally excited.

On witnessing the powerful contraction of a muscular fibre by the mere contact of certain metals, it was rational to conclude, that the nature and operation of the mysterious power of vital irritability might, at length, be discovered by a new train of scientific research. It is a curious fact, that an experiment so full of promise to the physiologist should have hitherto failed in affording him any assistance in his investigations, while the chemist, to whom it did not, at first, appear to offer any one single point of interest, has derived from it a new and highly important instrument of research, which has already, under the guidance of Davy, multiplied discoveries with such rapidity, and to such an extent, that it is not even possible to anticipate the limits of its power.

We have here, then, another striking instance of a great effect produced by means apparently insignificant. Who could have imagined it possible, that the spasmodic action occasioned in the limb of a frog, by the accidental contact of a pair of scissors, should have become the means of changing the whole theory of chemistry—of discovering substances, whose very existence was never suspected—of explaining the anomalous associations of mineral bodies in the veins of the earth—of protecting surfaces of metal from the corrosive action of the elements—of elucidating the theories of volcanoes and earthquakes—and, may we not add, of leading the way to a knowledge of the laws of terrestrial magnetism!

Such an unexpected extension of an apparently useless fact should dispose us to entertain a kinder regard for the labours of one another, and teach us to judge with diffidence of the abstract results of science. A discovery which may appear incapable of useful application to-day, may be our glory to-morrow,—it may even change the face of empires, and wield the destiny of nations.

The conic sections of Apollonius Pergæus remained useless for two thousand years: who could have supposed that, after the lapse of twenty centuries, they would have formed the basis of astronomy?—a science giving to navigation safety, guiding the pilot through unknown seas, and tracing for him in the heavens an unerring path to his native shores.

Some apology may be necessary for this digression; but I confess the subject has always appeared to me to be capable of much interesting illustration, and I heartily concur in the opinion expressed by the accomplished author of "Lettres à Sophie"—"*L'Histoire des grands effets par les petites causes ferait un livre bien curieux.*"

CHAPTER VI.

The History of Galvanism divided into six grand Epochs.—Davy extends the experiment of Nicholson and Carlisle.—His Pile of one metal and two fluids.—Dr. Wollaston advocates the doctrine of oxidation being the primary cause of Voltaic Phenomena.—Davy's modification of that theory.—His Bakerian Lecture of 1806.—He discovers the sources of the Acid and Alkaline matter eliminated from water by Voltaic action.—On the nature of Electrical decomposition and transfer.—On the relations between the Electrical energies of bodies, and their Chemical Affinities.—General developement of the Electro-chemical Laws.—Illustrations, Applications, and Conclusions.

THE History of Galvanism may be divided into six grand epochs; each being distinguished by the discovery of facts variously interesting from their novelty, and from the extent and importance of their applications.

It cannot be expected that I should enter into a minute history of the science; such a labour would require a distinct work for its accomplishment. I shall therefore follow the plan of the architect, who in presenting a finished drawing of a part, sketches a faint outline of the whole edifice to which it belongs, in order that its fair proportions may appear in proper breadth and relief.

THE FIRST EPOCH may be considered as arising out of the fundamental fact discovered by Galvani in 1790—that the contact of two different metals with the nerve of a recently killed frog will excite distinct muscular contractions.

THE SECOND EPOCH may be dated from the discovery of what might be termed *Organic* Galvanism, or the production of its influence, without the presence of animal organs, by the peculiar action of metals upon water, as first observed by Dr. Ash.

THE THIRD EPOCH will long be celebrated on account of the discovery of the accumulation of the Galvanic power, by the invention of the pile of

Volta, made known in the first year of the present century, and which so distinctly exhibited the analogy between Galvanism and Electricity, that the energy thus excited is now generally spoken of as "*Voltaic Electricity.*"

The fourth Epoch may be considered as founded upon the knowledge of the general connexion between the excitement of Voltaic electricity and chemical changes.

The fifth Epoch is exclusively indebted for its origin to Davy—the establishment of the general law, that Galvanism decomposes all compound bodies, and that the decomposition takes place in a certain determinate manner.

The sixth and last Epoch is founded upon the discovery of the relations subsisting between electricity and magnetism; giving origin to a new branch of science, which has been distinguished by the name of "Electro-Magnetism."

Galvani,* from the moment of his first discovery, always referred the effects he produced to an electrical origin, but he considered that the metals employed merely acted as conductors, which effected a communication between the different parts of an animal, naturally, or by some process of nature, in opposite states of electricity, and that the muscular contractions took place during the restoration of the equilibrium.

Until the researches of Dr. Ash,† Ritter, Fabroni, and Creve, had been made known, the Galvanic influence was generally considered as existing only in the living organs of animals, from which it might be elicited by certain processes.

In the Bakerian Lecture‡ read before the Royal Society in 1826, Davy, in

* The simple fact relating to the action of metals on the animal organs, was certainly not first observed by Galvani, but by Sulzer, who has described the sensation of taste produced by the contact of lead and silver with the tongue, in his *Théorie des Plaisirs,* in 1767.

† M. Humboldt (*Ueber die gereize Faser,* l. 473, 1797,) quotes part of a letter from Dr. Ash, in which it is said that, "if two finely polished plates of homogeneous zinc be moistened and laid together, little effect follows; but if zinc and silver be tried in the same way, the whole surface of the silver will be covered with oxidated zinc. Lead and quicksilver act as powerfully upon each other, and so do iron and copper. M. Humboldt says, that, in repeating this experiment, he saw air bubbles ascend, which he supposes to have been hydrogen gas from the decomposition of water.

‡ As this lecture will be frequently mentioned in the progress of these Memoirs, in connexion with most important discoveries, it may be interesting to the reader to learn something of its foundation and design. I have therefore collected the necessary information from the Minutes of the

giving a retrospective view of the progress of Electro-chemical Science, very justly remarks, that the true origin of all that has been done in this department of philosophy was the accidental discovery of Nicholson and Carlisle, of the decomposition of water by the pile of Volta, on the 30th of April, in the year 1800; which was immediately followed by that of the decomposition of certain metallic solutions, and by the observation of the separation of alkali on the negative plates of the apparatus. Mr. Cruickshank, in pursuing these experiments, obtained many new and important results, such as the decomposition of the *muriates of magnesia, soda,* and *ammonia;* and also observed the fact that alkaline matter always appeared at the negative, and *acid* matter at the positive pole.*

No sooner had Davy become acquainted with the curious experiments of Nicholson and Carlisle, than, as we learn from his letter to Mr. Gilbert,† bearing the date of July 1800, he proceeded to repeat them. Indeed, it was the early habit of his mind not only to originate enquiries, but without delay to examine the novel results of other philosophers; and in numerous instances it would seem, that he only required to confirm their accuracy before he succeeded in rendering the application of them subservient to farther discovery. This was certainly the case with respect to the subject before us; he was a discoverer as soon as he became an enquirer. It is admirable to observe with what a quick perception he discovered the various bearings of a new fact, and with what ingenuity he appropriated it for the explanation of previously obscure phenomena. In referring to the "Additional Observations" appended to his "Chemical Researches," we shall find that the moment he became

Royal Society. Mr. Baker is well known in the history of science, as an accurate observer with the microscope, and as the author of several works on the subject. By his will, dated July 1763, he bequeathed the sum of one hundred pounds, the interest of which he directed "to be applied for an Oration or Discourse, to be read or spoken yearly by some one of the Fellows of the Royal Society, on such parts of Natural History, or Experimental Philosophy, at such time, and in such manner, as the President and Council of the said Society shall please to order and appoint; on condition, nevertheless, that if any one year shall pass after the payment of the said hundred pounds, without such oration or discourse having been read or spoken at some Meeting of the said Royal Society, the said hundred pounds shall then become forfeited, and shall be repaid by the said Society to his executors," &c. Baker died in November 1774, and in the following year a Fellow was nominated to read the lecture. It is a whimsical circumstance, that the first lecturer should have been PETER WOULFE, the last of the alchemists. The names of the successive lecturers were as follow:—Dr. Ingenhouz, Mr. Cavallo, Mr. Vince, Dr. Wollaston, Dr. Young, Sir H. Davy, Mr. Brande, Captain Kater, Captain Edward Sabine, and Mr. Herschel.

* Nicholson's Journal, Vol. IV. p. 190.

† See page 58.

acquainted with the experiments of Dr. Ash, he proceeded to enquire how far the fact, previously noticed by himself, of the conversion of nitrous *gas* into nitrous *oxide*, by exposure to wetted zinc, might depend upon galvanic action.

In the month of September 1800, he published his first paper on the subject of Galvanic Electricity, in Nicholson's Journal, which was followed by six others, in which he so far extended the original experiment of Nicholson and Carlisle, as to show that oxygen and hydrogen might be evolved from separate portions of water, though vegetable and even animal substances intervened; and conceiving that all decompositions might be *polar*, he electrised different compounds at the different extremities, and found that sulphur and metallic bodies appeared at the *negative* pole, and oxygen and azote at the *positive* pole, though the bodies furnishing them were separated from each other. Here was the dawn of the Electro-chemical theory.

In a letter to Mr. Gilbert, already printed in these memoirs,* he announced his opinion that Galvanism is a process principally chemical; and, in a subsequent communication† to the same gentleman, written on the eve of his departure for Bristol to the Royal Institution, we discover a farther developement of the same theory, which, although modified by future researches, became, as we shall hereafter find, materially instrumental in establishing juster views of the nature of Voltaic action.

As soon as it was discovered that galvanic power might be excited by the contact of metals, without the interposition of animal organs, it was imagined that the electricity was set in motion by the contact of bodies possessing different conducting powers, without any reference to the chemical action which accompanied the process. This theory was naturally suggested by the fact discovered by Mr. Bennett several years before—that *electricity is excited by the mere contact of different metals:* thus, when a plate of copper and another of zinc, each furnished with an insulating glass handle, are made to touch by their flat surfaces, the zinc, after separation, exhibits *positive*, and the copper *negative* electricity. In this case, it is fair to conclude that a certain quantity of electricity had moved from the copper to the zinc.

On trying other metals, Volta found that similar phenomena arose; from which property such bodies have been denominated "*motors*" of electricity, and the process which takes place *electro-motion*, terms which have since been sanctioned and adopted by Davy.

* See page 73. † Page 79.

It is on this transference of electricity from one surface to another, by simple contact, that Volta explains the action of the pile invented by himself, as well as that of all similar arrangements. The interposed fluids, on this hypothesis, have no effect as chemical agents, in producing the phenomena; they merely act as conductors of the electricity.

We have seen how early Davy had observed the intimate connexion subsisting between the electrical effect, and the chemical changes going on in the pile, and that he accordingly drew the conclusion of the dependance of the one upon the other. In fact, the most powerful Voltaic combinations are those formed by substances that act chemically upon each other with the greatest energy; whilst such as undergo no chemical change exhibit no electrical powers: thus zinc, copper, and nitric acid form a powerful battery, whilst silver, gold, and water, which do not act upon each other, produce no sensible effect in a series of the same number.

Although, in this obscure region of research, we are as yet unable to discover the nature of the power by which electricity is accumulated, it was a considerable step towards a true theory to have ascertained the insufficiency of the proposition that had been offered in explanation of the phenomena.

An investigation into the chemical activity of the pile led Davy to the discovery of a new series of facts, to which we find an allusion in his former letters to Mr. Gilbert, and which subsequently formed the basis of his first communication read before the Royal Society on the 18th of June in the same year.

All the combinations analogous to the Voltaic pile had hitherto consisted of a series containing, at least, *two* metallic bodies, (or one metal and charcoal,) and a stratum of fluid. Davy discovered that an accumulation of galvanic energy, exactly similar to that in the common pile, might be produced by the arrangement of *single* metallic plates with *different* strata of fluids; so that, instead of composing a battery with *two* metals and *one* fluid, he succeeded in constructing it with *one* metal and *two* fluids; provided always that oxidation, or some equivalent chemical change, should proceed on one of the metallic surfaces only.

In describing these combinations of a single metal with two fluids, he divides them into three classes, following in the arrangement the order of time with regard to their discovery.

In the First Class, one side of the metallic plate is oxidated; in the Second, a sulphuret is formed on one of its surfaces; and in the Third, both sides are acted upon, the metal becoming a *sulphuret* on one of its surfaces, and an *oxide* on the other.

The apparatus which he employed for these experiments is preserved in the laboratory of the Royal Institution. It consists of a trough, containing grooves capable of receiving the edges of the different plates necessary for the arrangement, one half of which are composed of horn, the other half of some one metal.

When the apparatus was used, the cells were filled, in the galvanic order, with the different solutions, according to the class of the combination, and connected in pairs with each other, by slips of moistened cloth carried over the non-conducting plates.

At the meeting of the Royal Society, following that on which the above interesting facts were communicated, Dr. Wollaston presented a memoir of considerable importance, entitled, "Experiments on the Chemical Production and agency of Electricity;" in which he strongly advocates the truth of that theory which recognises metallic oxidation as the *primary* cause of the Voltaic phenomena. This paper is also farther important as it proves, by most ingeniously devised experiments, not only the similarity of the means by which both common and galvanic electricity are excited, but also the resemblance existing between their effects; shewing, in fact, that they are both essentially the same, and confirming the opinion, that all the apparent differences may depend upon differences in intensity and quantity.

Acting upon this principle, Dr. Wollaston succeeded in producing a very close imitation of the chemical action of galvanism by common electricity; such, for example, as the decomposition of water, and other effects of oxidation and deoxidation. In the prosecution of this train of research, Dr. Wollaston displays, in a very striking manner, that attention to minute arrangement which so remarkably characterised all his manipulations. I particularly allude to the expedients by which he reduced the extremity of a gold wire, in order to apportion the strength of the electric charge to the quantity of water submitted to its influence.

Although it is now very generally admitted, that the chemical agency of the fluids upon the metals employed is highly essential to the maintenance of Voltaic action, there still remains considerable doubt, as to how far we are entitled to regard it as the first in the order of phenomena.

At a later period of his researches, Davy suggested as a correction, or rather modification, of the theory of Volta, that the electro-motion produced by the contact of the metals might be the primary cause of the chemical changes; and that such changes were in no other way efficient, than in restoring the electric equilibrium thus disturbed; it was farther held, that this equilibrium could not be permanent, that it could in fact be only momentary; since, in consequence of the imperfect conducting power of the interposed fluid, the zinc and copper-plates, by their electro-motive power, would again assume their opposite states of electricity; and that these alternate changes would occur, as long as any of the fluid remained undecomposed. In a Voltaic arrangement, then, there would appear to exist, if the expression may be allowed, a kind of electrical see-saw; the apposition of the metals destroying the equilibrium, and the resulting chemical changes again restoring it. It has, however, been very justly observed, that the application of electricity, as an instrument of chemical decomposition, has most fortunately no connexion with such theories, and that the study of its effects may be carried on without reference to any hypothetical notions concerning the origin of the phenomena.

An interval of nearly five years had elapsed between the first communication which Davy made on this subject, and the Bakerian lecture which is immediately to be considered. During this period several new facts had been added by different experimentalists, but they were scattered, disjointed, and totally unconnected with each other by any rational analogies.

The constant appearance of acid and alkaline matter in pure water, when submitted to the influence of the Voltaic pile, gave rise to the most extravagant speculations and discordant hypotheses. Various statements were made, both in Italy and England, respecting the *generation* of muriatic acid, and that of the fixed alkalies, under these circumstances. Mr. Sylvester affirmed, that if two separate portions of water were electrised out of the contact of substances containing alkaline or acid matter, acid and alkali would, nevertheless, be produced.

Some philosophers sought to explain the phenomenon from the salts contained in the fluids of the trough, which they imagined might, by some unsuspected channel, find their way into the water under examination. Others believed that they were actually *generated* by the union of the electric fluid with the water, or with one or both of its elements; so that, up to the time of Davy's masterly researches, the subject was involved in the greatest obscurity; and whether the saline matter was liberated from unknown combinations, or at once formed by the union of its elements, was a question upon which the greatest chemists entertained different opinions.

The Bakerian Lecture, read before the Royal Society on the 20th of November 1806, not only set this question for ever at rest, but unfolded the mysteries of general Voltaic action; and, as far as theory goes, may almost be said to have perfected our knowledge of the chemical agencies of the pile.

This grand display of scientific light burst upon Europe like a splendid meteor, throwing its radiance into the deepest recesses, and opening to the view of the philosopher new and unexpected regions.

I shall endeavour to offer as popular a review of this celebrated memoir, as the abstruse and complicated nature of its subjects will allow; and I shall be careful in pointing out the successive stages of the enquiry; for we are all too much in the habit of exclusively looking after results; whereas an examination of the steps by which they were attained is far more important, not only to the fame of the discoverer, but to ourselves, as the means of instruction.

The subjects investigated in this memoir are arranged under the following divisions.

1. " On the changes produced in Water by Electricity.

2. " On the agencies of Electricity in the decomposition of various compound Bodies.

3. " On the transfer of certain constituent Parts of Bodies by the action of Electricity.

4. " On the passage of Acids, Alkalies, and other Substances, through various attracting chemical menstrua, by means of Electricity.

5. " Some general Observations on these Phenomena, and on the mode of Decomposition and Transition.

6. " On the General Principles of the chemical changes produced by Electricity.

7. " On the Relations between the Electrical Energies of bodies and their Chemical Affinities.

8. " On the mode of action of the Pile of Volta, with Experimental Elucidations.

9. " On some General Illustrations and Applications of the foregoing facts and principles."

With respect to the first of these divisions, comprehending a history of the changes produced in water by electricity, it is worthy of particular notice, that as early as the year 1800, while residing at Bristol, Davy had discovered that when separate portions of distilled water, filling two glass tubes connected by moist bladders, or any moist animal or vegetable substance, were submitted to the electrical action of the Voltaic pile, by means of gold wires, a *nitro-muriatic* solution of gold appeared in the tube containing the positive wire, and a solution of soda in the opposite tube; but he soon ascertained that the muriatic acid owed its appearance to the animal or vegetable matters employed; for when the same fibres of cotton were used in successive experiments, and washed after every process in a weak solution of nitric acid, the water in the apparatus containing them, though acted upon for a great length of time with a very strong power, at length produced no effect upon a solution of nitrate of silver.

In every case in which he had procured much soda, the glass* at the point of contact with the wire seemed considerably eroded; when by substituting an agate for a glass cup, no fixed saline matter could be obtained. Its source therefore, in the former case, was evidently the glass.

With respect to Mr. Sylvester's experiment, already noticed, it was sufficient to say that he conducted his process in a vessel of *pipe-clay*, which not only contains lime, but may also include in its composition some of the combinations of a fixed alkali.

On resuming the enquiry, it was Davy's first care to remove every possible source of impurity; he accordingly procured cups of agate, which, previously to being filled, were boiled for several hours in distilled water; and a piece of very white and transparent *amianthus*, a substance first proposed for this purpose by Dr. Wollaston, having been similarly purified, was made to connect the vessels together. Thus was every apparent source of fallacy removed; but still, after having been exposed to Voltaic action for forty-eight hours, the water in the positive cup gave indications of muriatic acid, and that in the negative cup, of soda! The result was as embarrassing as it was unexpected; but it was far from convincing him that the bodies thus obtained were *generated*:—but whence arose the saline matter? Did the agate, after every precaution, still contain some very minute portion of saline matter, not easily discoverable by chemical tests? To determine this question, the experiment was repeated a second, a third, and a fourth time; the quantities of saline matter diminished in every successive operation, which sufficiently

* It is perhaps a fact not very generally known, that glass, to a certain extent, is decomposable by water; if some of it in a powdered state be triturated with distilled water, in a short time the turmeric test will indicate a portion of alkali in solution.

proved that the agate must at least have been *one* of the sources sought for; but four additional repetitions of the process convinced the operator that it could not be the only one; that there must exist some other source from which the alkali proceeded, since it continued to appear to the last, in quantities sufficiently distinct, and apparently equal, in every experiment. This was extremely perplexing; every precaution had been taken—the agate cups had even been included in glass vessels, out of the reach of the circulating air — all the acting materials had been repeatedly washed with distilled water; and no part of them in contact with the fluid had ever touched the fingers.

The water itself then, however pure it might appear, must have furnished the alkali. The experiments were repeated in cones of the purest gold, and the water contained in them was submitted to Voltaic action for fourteen hours; the result was, that the acid increased in quantity as the experiment proceeded, and at length became even sour to the taste. On the contrary, the alkaline properties of the fluid in the opposite cone shortly obtained a certain intensity, and remained stationary.

On the application of heat, the alkaline indications became less vivid, although there always remained, after the operation, sufficient evidence to prove that a portion at least was fixed, although probably mixed with ammonia.

The acid, as far as its properties could be examined, agreed with those of pure nitrous acid, having an excess of nitrous gas.

It was now impossible to doubt that the water held in solution some substance which was capable of yielding alkaline matter, but which, from the minuteness of its quantity, had soon been exhausted.

The next step, therefore, was to submit the water to a still more rigorous examination, which he did by evaporating it in a vessel of silver; when he had the satisfaction to discover the 1-70th of a grain of saline matter.

The water, thus purified in a vessel of silver, was again subjected to Voltaic action in the cones of gold. After two hours, there was only the slightest possible indication of alkali; and this was not, as before, *fixed*, but entirely *volatile*.

In every one of these experiments, acid matter had been produced, and it always presented the character of nitrous acid. Two of the great sources of foreign matter had been detected and removed, viz. the vessels, and the water employed; it still however remained to be explained, how nitrous acid and ammonia could be produced in cases where pure water and pure vessels had been used. In no part of this elaborate enquiry is the penetration of Davy more striking, than in his reasonings upon this problem, and in the beautiful experiments which his sagacity suggested for its solution.

It occurred to him, that the nascent oxygen and hydrogen of the water might respectively combine with a portion of the nitrogen of the common air, which is constantly dissolved in that fluid; but if this were the case, how did it happen that the production of nitrous acid was progressive, while that of the alkali was limited? The experiments of Dr. Priestley, on the absorption of gases by water, at once suggested themselves to his mind as being capable of solving this last difficulty; for that distinguished philosopher had shown, that hydrogen, during its solution in water, expelled the nitrogen, whereas oxygen and nitrogen were capable of co-existing in a state of solution in that fluid. It was, however, necessary to confirm the truth of this explanation by experiment, and he accordingly introduced the two cones of gold, containing purified water, under the receiver of an air-pump; the exhaustion was effected, and the Voltaic pile brought to act upon the water thus circumstanced; after eighteen hours the result was examined, when the water in the negative cone produced no effect upon prepared litmus, but that in the positive vessel did give it a tinge of red barely perceptible.

Had his series of experiments terminated here, the truth of his conclusions would have been established by the comparatively small proportion of acid formed in this latter experiment; but he determined to repeat it under circumstances, if possible, still more unexceptionable and conclusive. Having, therefore, arranged the apparatus as before, he exhausted the receiver, and then filled it with hydrogen gas from a convenient air-holder; he made even a second exhaustion, to ensure the highest accuracy, and then again introduced carefully prepared hydrogen. The Voltaic process was continued during twenty-four hours, and at the end of that period it was found that neither the water in the positive, nor in the negative vessels, altered the tint of litmus in the slightest degree.

Thus did he succeed in exposing the three great sources of fallacy which had so long misled chemists, with regard to the generation of acid and alkaline matter in Voltaic experiments, viz.—The impurities of the vessels—the foreign matter contained in the water—and the compounds generated by the combination of the nitrogen of atmospheric air with the elements evolved from water; and thus did he establish, by an unbroken chain of incontrovertible evidence, the important truth, that "water, chemically pure, is decomposed by electricity into gaseous matter alone — into oxygen and hydrogen."

Out of the foregoing train of research, very naturally sprang the consideration of the *decomposing agencies of Electricity.* It had been constantly observed, that, in all electrical changes connected with the presence of acid and alkaline matter, the former uniformly collected around the positive, and the latter around the negative surface of the apparatus.

In one of the earliest experiments, Davy had also noticed that glass underwent decomposition, and that its alkali always passed to the negative surface. He was, therefore, led to enquire whether, through electrical agency, different solid earthy compounds, insoluble, or soluble with difficulty in water, might not be made to undergo a similar decomposition. We shall find that the results of the trials were decisive and satisfactory. For conducting experiments of this description, he hit upon the happy expedient of constructing the cups with the materials which he wished to submit to experiment, and then by introducing water into them, and forming the necessary connexion by means of asbestus, he completed the Voltaic circuit. In this manner he submitted to experiment *sulphate of lime*, *sulphate of strontia*, *fluate of lime*, *sulphate of baryta*, &c. and with analogous results; the acid element in each case passing to the positive, and the earthy base to the negative cup.

As, in the above experiments, the bodies under examination were presented in considerable masses, and exposed large surfaces to the electric action, it became necessary to enquire whether minute portions of acid and alkaline matter could, by the same agency, be disengaged from solid combinations. This point was very readily elucidated. A piece of fine grained basalt, which, by a previous analysis, had been found to contain 3·5 per cent. of soda, nearly ·5 of muriatic acid, and fifteen parts of lime, having been divided into two properly-shaped pieces, and a cavity, capable of containing twelve grains of water, been drilled in each, was submitted, as in former experiments, to the action of the pile. At the end of ten hours the result was examined with care, when it appeared that the positively electrified water had the strong smell of oxy-muriatic acid, and copiously precipitated nitrate of silver, while that which was negative affected turmeric, and left by evaporation a residuum which appeared to consist of lime and soda.

A part of a specimen of compact zeolite from the Giants' Causeway, and vitreous lava from Ætna, were each treated in a similar manner, and with results equally satisfactory.

Having thus settled the question with regard to the disengagement of the saline parts of bodies insoluble in water, he proceeded to extend and multiply his experiments on soluble compounds, the decomposition of which, as might have been supposed, always proceeded with greater rapidity, and furnished results more perfectly distinct. In these processes he employed the agate cups, with platina wires, connected by amianthus moistened with pure water; the solutions were introduced into these cups, and the electrifying power applied in the manner already described. In this way, *sulphate of potash, sulphate of soda, nitrate of potash, phosphate of soda,* &c. were respectively examined; and in every case the acid, after a certain interval, collected in the cup containing the positive wire, and the alkalies and earths in that containing the negative wire.

When metallic solutions were employed, metallic crystals or depositions were formed on the negative wire, and oxide was likewise deposited around it, while a great excess of acid was found in the opposite cup.

With respect to the transfer of the constituent Parts of Bodies by Electric Action, several original experiments were instituted, and some important conclusions established.

Several facts had been stated, which rendered it probable that the saline elements evolved in decompositions by electricity, were capable of being transferred from one electrified surface to another, according to their usual order of arrangement; but to demonstrate this clearly, farther researches were required, and Davy proceeded to supply the necessary evidence. He connected one of the cups of sulphate of lime before mentioned with a cup of agate, by means of asbestus, and filling them with purified water, connected them with the battery. In about four hours, a strong solution of lime was found in the agate cup, and sulphuric acid in the cup of sulphate of lime. By reversing the order of arrangement, and carrying on the process during a similar period, the sulphuric acid appeared in the agate cup, and the lime in the opposite vessel. In both these experiments (the acid in the one case, and the lime in the other), the elements of the substance must have passed, in an imperceptible form, along the connecting line of asbestus into the opposite vessel.

Many trials were made with other saline bodies, and with results equally satisfactory; the base always passing into the vessel rendered negative, and the acid into that which was positive.

The time required for these transmissions appeared to be, *cæteris paribus*, in some proportion to the length of the intermediate volume of water.

In the farther prosecution of the enquiry, Davy discovered a still more extraordinary series of facts. In the first place, he found that the contact of the saline solution with a metallic surface was not in the least necessary for its decomposition. He introduced purified water into two glass tubes, and connected with them, by means of amianthus, a vessel containing a solution of muriate of potash. In this case, the saline matter was distant from each of the wires at least two-thirds of an inch; and yet alkaline matter soon appeared in one tube, and acid matter in the other; and in sixteen hours moderately strong solutions of potash and muriatic acid had been formed.

The discovery of this fact became the key to that of others. He very naturally proceeded to enquire into the progress of the transfer, and into the course of the acid and alkaline elements; when, by the use of litmus and turmeric, he arrived at the following conclusion, — that acids and alkalies, during their electrical transference, passed through water containing vegetable colours without effecting in them any change. From which we are led to the consideration of the fourth division of the subject, viz. "On the Passage of Acids, Alkalies, and other Substances, through various attracting Chemical Menstrua, by Electricity."

As soon as it was discovered that a power generated by the Voltaic pile was capable of destroying elective affinity in the vicinity of the metallic points, it seemed reasonable to suppose, that the same power might also destroy it, or at least suspend its operation, throughout the whole of the circuit. The truth of such a supposition was at once placed beyond all doubt by the following very striking experiment.

Three tubes, the first containing a solution of *sulphate of potash*, the second a weak solution of *ammonia*, and the third, *pure water*, each being connected with the other in the usual manner by amianthus, were arranged in relation to the pile, as follow:—the *sulphate of potash* was placed in contact with the negatively electrified point, the *pure water* with the positively electrified point, while the solution of *ammonia* was made the middle link of the conducting chain; so that no sulphuric acid could pass to the positive point in the distilled water without passing through the ammoniacal solution.

In less than five minutes after the electric current had been completed, it was found, by means of litmus paper, that acid was in the act of collecting around the positive point; and in half an hour the result was sufficiently distinct for accurate examination.

Other experiments were made with a solution of lime, and with weak solutions of potash and soda, and the results were analogous. Muriatic acid, from muriate of soda, and nitric acid, from nitrate of potash, were also transmitted through concentrated alkaline menstrua, under similar circumstances, and with like effects.

Davy also made several experiments on the transition of alkaline and acid matter, through different neutro-saline solutions, the results of which were exactly such as theory would have anticipated.

In conducting, however, these experiments of electrical transference, there would appear to be one condition essential to their success, viz. that the solution contained in the intermediate vessel should not be capable of forming an insoluble compound with the substance transmitted through it; thus, for example, Davy found that *strontia* and *baryta* passed, like the other alkaline substances, very readily through muriatic and nitric acids; and *vice versa*, that these acids passed with equal facility through aqueous solutions of the earths in question; but when it was attempted to pass *sulphuric* acid through the same earthy solutions, or to pass the earths through the sulphuric acid, that then the results were of a very different character; the sulphuric acid, in its passage through the barytic solution, was arrested in its progress by the earthy body, and falling down as an insoluble compound with it, was carried out of the sphere of the electrical action, by which the power of transfer was destroyed. The same phenomena occurred whenever he attempted to pass muriatic acid through a solution of sulphate of silver. We now come to the next division—viz. "Some general Observations on these phenomena, and on the mode of Decomposition and Transition."

Davy considers that it will be a general expression of the facts relating to the changes and transitions by electricity, to say, that "hydrogen, the alkaline substances, the metals, and certain oxides, are attracted by negatively electrified, and repelled by positively electrified metallic surfaces; and on the contrary, that oxygen and acid substances are attracted by positively electrified, and repelled by negatively electrified metallic surfaces." And moreover, that these "attractive and repulsive forces are sufficiently energetic to destroy or suspend the usual operation of elective affinity."

Amidst all these wonderful phenomena, that perhaps which excites our greatest astonishment is the fact of the transfer of ponderable matter to a considerable distance, through intervening substances, and in a form that escapes the cognizance of our senses! Upon this question Davy offers the following remarks. "It is," says he, "very natural to suppose, that the repellent and attractive energies are communicated from one particle to another particle of the same kind, so as to establish a conducting chain in the fluid; and that the locomotion takes place in consequence; thus, in all the instances in which I examined alkaline solutions through which acids had been transmitted, I always found acid in them, as long as any acid matter remained at the original source. In time, by the attractive power of the positive surface, the decomposition and transfer undoubtedly become complete; but this does not affect the conclusion. In cases of the separation of the constituents of water, and of solutions of neutral salts forming the whole of the chain, there may possibly be a succession of decompositions and recompositions throughout the fluid."

We are next brought to a very important point in the enquiry—viz. "The consideration of the General Principles of the chemical changes produced by Electricity."

The experiment of Mr. Bennett, already alluded to, had shown that many bodies, when brought into contact, and afterwards separated from each other, exhibited signs of opposite states of electricity; but it is to the investigations of M. Volta that we are indebted for the clear developement of the fact; for he has distinctly proved it in the case of copper and zinc, and other metallic combinations, and he supposed that it might also take place with regard to metals and fluids.

In a series of experiments, made in the year 1801, on the construction of electrical combinations, by means of alternations of single metallic plates, and different strata of fluids, as explained upon a former occasion,* Davy had observed that, when acid and alkaline solutions were employed as the elements of these Voltaic combinations, the alkaline solutions always received the electricity from, and the acid always transmitted it to the metal. These principles seem to bear an immediate relation to those general phenomena of decomposition and transfer, which have been the subject of the preceding details.

In the most simple case of electrical action, the alkali which receives electricity from the metal would necessarily, on being separated from it, appear *positive;* whilst the acid, under similar circumstances, would be *negative;* and these bodies having respectively, with regard to the metal, that which may be called a positive and a negative electrical energy, in their repellent and attrac-

* Page 144.

tive functions, would seem to be governed by the common laws of electrical attraction and repulsion; the body possessing the positive energy being repelled by positively electrified surfaces, and that possessing the negative influence following the contrary order.

Davy made a number of experiments with the view of elucidating this idea, and of extending its application; and, in all cases, their results tended, in a most remarkable manner, to confirm the analogy.

He proceeded, by means of very delicate instruments, to ascertain the electrical states of single insulated acid and alkaline solutions, after their contact with metals; but the sources of errors were so numerous, as to render the results far from being satisfactory; but in experiments on dry and solid bodies, the embarrassments arising from evaporation, chemical action, &c. did not occur. When perfectly dry oxalic, succinic, benzoic, or boracic acid, either in the form of powder or crystals, were touched upon an extended surface with a plate of copper, insulated by a glass handle, the copper was found positive, the acid negative. When again metallic plates were made to touch dry lime, strontia, or magnesia, they became negative: in these latter experiments the effect was exceedingly satisfactory and distinct, a single contact upon a large surface being sufficient to communicate a considerable charge.

Numerous other trials were made, and the results confirmed the principle; and moreover proved, as might have been expected, that bodies possessing electrical conditions with regard to one and the same body, possessed them with regard to each other: for instance, a dry piece of lime became positively electrical by repeated contact with crystals of oxalic acid.

These results led him to reason more fully upon the " Relations between the Electrical energies of bodies and their chemical affinities."

As the chemical attraction subsisting between two bodies seems to be destroyed by giving to one of them an electrical condition opposite to that which it naturally possesses; and since the substances that combine chemically, as far as can be ascertained, exhibit opposite states of electricity, the relations between this energy and chemical affinity would appear to be sufficiently evident to warrant the conclusion at which Davy arrived, viz. that " the combinations and decompositions by electricity were referable to the law of electrical attractions and repulsions;" from which he advanced to the still more important step—" that chemical and electrical attractions were produced by the same cause, acting in one case on particles, in the other on masses."

From these views he is led to propose the electrical powers, or the forces required to disunite the elements of bodies, as a test or measure of the intensity of chemical attraction. An accurate investigation into this connexion, which may be called the *Electro-dynamic* relations of bodies to their combining masses or proportional numbers, would be the first step towards fixing the science of Chemistry on the permanent foundation of the mathematics.

If then the power of electrical attraction and repulsion be identified with chemical affinity, or rather, if both be dependent upon the same cause, it will follow that two bodies which are naturally in opposite electrical states, may have these states sufficiently exalted to give them an attractive power superior to the cohesive force opposed to their union; when a combination will take place which will be more or less energetic, as the opposed forces are more or less equally balanced. Again, when two bodies, repellent of each other, act upon a third with different degrees of the same electrical energy, the combination will be determined by the degree; or, if bodies having different degrees of the same electrical energy with respect to a third, have likewise different energies with respect to each other, there may be such a balance of attracting and repelling forces as to produce a triple compound; and by the extension of this reasoning, complicated chemical union may be easily explained.

Whenever bodies brought by artificial means into a high state of opposite electricities are made to restore the equilibrium, heat and light are the common consequences. It is perhaps an additional circumstance in favour of the theory to state, that heat and light are likewise the results of all intense chemical action. And as in certain forms of the Voltaic battery, where large quantities of electricity of low intensity act, heat without light is produced; so in slow chemical combinations there is an increase of temperature without any luminous appearance.

The effect of heat in producing combination may be easily explained according to these ideas; it not only gives more freedom of motion to the particles, but in a number of cases it seems to exalt the electrical energies of bodies:—glass, the tourmaline, sulphur, and some others, afford familiar instances of this latter species of energy.

In general, when the different energies are strong and in perfect equilibrium, the combination ought to be quick, the heat and light intense, and the new compound in a neutral state. This would seem to be the case in the combination of oxygen and hydrogen, which form water, a body apparently neutral in electrical energy to most others; and also in the circumstances of the union of the strong alkalies and acids. But where one energy is feeble, and the other strong, all the effects must be less vivid; and the compound, instead of being neutral, ought to exhibit the excess of the stronger energy.

The grand principle thus developed may enable us to obtain new and useful indications of the composition of bodies, by ascertaining the character of their electrical energies; and we now find, in all modern works of Chemistry, that bodies are arranged according to their electrical relations; and are said to be Electro-positive, or Electro-negative, according to their polarities. The advantage of such an arrangement must be freely acknowledged, for it has been the means of establishing analogies * of the utmost importance in chemistry, of which I shall adduce some striking examples in a subsequent part of the present work, when I shall endeavour to offer a general view of the revolution which chemical science has undergone during the investigations of Davy, and contemporary philosophers.

After some further enquiries into the theory of the Voltaic pile,† to which an allusion has been already made, the author offers additional reasons for supposing the decomposition of the chemical menstrua essential to the continued electro-motion of the pile; and if the fluid medium could be a substance incapable of decomposition, there is every reason to believe the equilibrium would be restored, and the motion of the Electricity cease. Having shewn the effects of *induction*, in increasing the electricity of the opposite plates, he arrives at the important conclusion, that in a Voltaic arrangement the *intensity of the Electricity increases with the number, but the quantity with the size of the plates.* A theory which was subsequently confirmed by the experiments of Mr. Children.

The paper concludes with " some general illustrations and applications of the foregoing facts and principles," and which the author thinks will readily suggest themselves to the philosophical enquirer. They offer, for instance, very easy methods of separating acid and alkaline matter, where they exist in combination in mineral substances; and, in like manner, they suggest the application of electrical powers for effecting the decomposition of animal and vegetable bodies.

On exposing a piece of muscular fibre to the action of the battery, he

* It will be sufficient for my present purpose to point out those existing between *Chlorine*, *Iodine*, and *Bromine*.

† See page 146.

found that potash, soda, ammonia, lime, and oxide of iron, were evolved on the negative side, and the three mineral, together with the phosphoric, acids, were given out on the positive side.

A laurel leaf, similarly treated, yielded to the negative vessel resin, alkali, and lime; while in the positive one there collected a clear fluid, which had the smell of peach-blossoms, and which, when neutralized by potash, gave a blue-green precipitate to a solution of sulphate of iron, so that it must have contained *Prussic Acid.*

A small plant of mint, in a state of healthy vegetation, on being made the medium of connection in the battery, yielded potash and lime to the water negatively electrified, and acid to that positively electrified. The plant recovered after the process; but a similar one, that had been electrified during a longer period, faded and died.

These facts would seem to show, that the electrical powers of decomposition even act upon vegetable matter in its living condition; and phenomena are not wanting to show that they operate also on the system of living animals. When the fingers, after having been carefully washed with pure water, are brought in contact with this fluid in the positive part of the circuit, acid matter is rapidly developed, having the character of a mixture of muriatic, phosphoric, and sulphuric acids; and if a similar trial be made in the negative part, fixed alkaline matter is as quickly developed.*

Davy thinks that the acid and alkaline taste produced upon the tongue during galvanic experiments, depends upon the decomposition of the saline matter contained in the living animal substance, and perhaps in the saliva; and he farther observes that, as acid and alkaline substances are thus evidently capable of being separated from their combinations in living systems by electrical powers, there is reason to believe that, by converse methods, they might also be introduced into the animal economy, or made to pass through the animal organs; and the same thing may be supposed of metallic oxides; and that these ideas ought to lead to some new investigations in Medicine and Physiology.

He thinks it by no means improbable, that the electrical decomposition of the neutral salts, in different cases, may admit of economical applications; and that well-burnt charcoal and plumbago, or charcoal and iron, might be made the exciting powers for such a purpose. Such an arrangement, if erected upon

* Reflecting upon this and similar facts, it has occurred to me that Voltaic electricity might be applied for removing the blue colour in the skin, occasioned by the internal use of nitrate of silver. I hope to be able very shortly to submit this theory to the test.

a scale sufficiently extensive, with the medium of a neutro-saline solution, would, in his opinion, produce large quantities of acids and alkalies with very little trouble or expense.

Alterations in chemical equilibrium are constantly taking place in Nature, and Davy considers it probable that the electric influence, in its faculties of decomposition and transference, may considerably interfere with the chemical changes occurring in different parts of our system.

The electrical appearances which precede earthquakes and volcanic eruptions, and which have been described by the greater number of the observers of these awful events, admit also of easy explanation on the principles that have been stated.

Besides the cases of sudden and violent change, Davy considers there must be constant and tranquil alterations, of which electricity, produced in the interior strata of the globe, is the active cause; thus, where *pyritous* strata and strata of *coal-blende* occur,—where the pure metals or the sulphurets are found in contact with each other, or with any conducting substances,—and where different strata contain different saline menstrua, he thinks electricity must be continually manifested; and it is probable that many mineral formations have been materially influenced, or even occasioned, by its agencies.

In an experiment which he performed of electrifying a mixed solution of the muriates of iron, copper, tin, and cobalt, contained in a positive vessel, all the four oxides passed along the connecting asbestus into a positive vessel filled with distilled water, while a yellow metallic crust formed on the wire, and the oxides arranged themselves in a mixed state around the base of it.

In another experiment, in which carbonate of copper was diffused through water in a state of minute division, and a negative wire was placed in a small perforated cube of zeolite in the water, green crystals collected round the cube; the particles not being capable of penetrating it.

By a multiplication of such instances, Davy remarks, that the electrical power of transference may be easily conceived to apply to the explanation of some of the principal and most mysterious facts in geology;* and by imagining a scale of feeble powers, it would be easy to account for the association of the insoluble metallic and earthy compounds containing acids.

* During the contentions of the Neptunists and Plutonists, alluded to in a former part of this work, specimens were produced exhibiting the intermixture of mineral bodies, which was completely hostile to all theory. These anomalies now receive a plausible explanation from the agencies of Voltaic electricity.

" Natural electricity," observes our philosopher, " has hitherto been little investigated, except in the case of its evident and powerful concentration in the atmosphere. Its slow and silent operations in every part of the surface will probably be found more immediately and importantly connected with the order and economy of nature; and investigations on this subject can hardly fail to enlighten our philosophical systems of the earth, and may possibly place new powers within our reach."

Thus concludes one of the most masterly and powerful productions of scientific genius. I may perhaps have been considered prolix in recording the progressive researches by which he arrived at his results; but let it be remembered, that the great fame of Davy, as an experimental philosopher, rests upon this single memoir, and though the secondary results to be hereafter considered, may be more dazzling to ordinary minds, yet in the judgment of every scientific observer, they must appear far less glorious than the discovery of the primitive laws. Let me ask whether Sir Isaac Newton does not deserve greater fame for his invention of fluxions, than for the calculations performed by the application of them? I do not hesitate in comparing these great philosophers, since each has enlightened us by discoveries alike effected by means invented by himself. Not only did both unlock the caskets of Nature, but they had the superior merit of planning and constructing the key.

I challenge those, who have carefully followed me through the details of the preceding memoir, to shew a single instance in which accident, so mainly contributory to former discoveries in electricity, had any share in conducting its author to truth. Step by step did he, with philosophic caution and unwearied perseverance, unfold all the particular phenomena and details of his subject; his genius then took flight, and with an eagle's eye caught the plan of the whole.—A new science has been thus created; and so important and extensive are its applications, so boundless and sublime its views, that we may fairly anticipate the fulfilment of those prophetic words of Dr. Priestley, who in the preface to his History of Electricity,* exclaims—" Electricity seems to be giving us an inlet into the internal structure of bodies, on which all their sensible properties depend. By pursuing this new light, therefore, the bounds of natural science may possibly be extended beyond what we can

* The History and Present State of Electricity; by Jos. Priestley, LL.D. F.R.S., &c. London, 1795.

now form any idea of. New worlds may open to our view, and the glory of the great Sir Isaac Newton himself, and all his contemporaries, be eclipsed by a new set of philosophers, in quite a new field of speculation. Could that great man revisit the earth, and view the experiments of the present race of electricians, he would be no less amazed than Roger Bacon, or Sir Francis, would have been at his." In our turn, we may ask, what would be the astonishment—what the delight of Dr. Priestley, could he now witness the successful results of Voltaic research—and what would he say of that mighty genius who has demonstrated the relations of electrical energy to the general laws of chemical action?* It was his good fortune to have witnessed the discovery which identified electricity with the lightning of the thunder cloud: what would he have said of that which identified it with the magnetism of the earth! Of this at least we may be certain, that he would have expunged from his history the passage in which he observes—" Electrical discoveries have been made so much by accident, that it is more the powers of nature, than of human genius, that excite our wonders with respect to them."

* Dr. Priestley augured much from the talents of Davy. After the publication of his first paper on Galvanism, he wrote to him from America, and expressed the pleasure he felt on finding his favourite subject in such able hands. Priestley died in 1804, and therefore did not witness Davy's success.

CHAPTER VII.

The unfair rivalry of Philosophers.—Bonaparte the Patron of Science.—He liberates Dolomieu.—He founds a Prize for the encouragement of Electric researches.—His letter to the Minister of the Interior.—Proceedings of the Institute.—The Prize is conferred on Davy.—The Bakerian Lecture of 1807.—The Decomposition of the Fixed Alkalies—Potassium—Sodium.—The Questions to which the discovery gave rise.—Interesting Extracts from the Manuscript notes of the Laboratory.—Potash decomposed by a chemical process.—Letters to Children, and Pepys.—The true nature of Potash discovered.—Whether Ammonia contains oxygen.—Davy's severe Illness.—He recovers and resumes his labours.—His Fishing Costume.—He decomposes the Earths.—Important views to which the discovery has led.

It must be confessed that there has too frequently existed amongst philosophers a strange and ungenerous disposition to undervalue the labours of their contemporaries. If a discovery be made, its truth and importance are first questioned; and should these be established, then its originality becomes a subject of dispute.

Truth, although she may have been rarely held fast, has been frequently touched * in the dark; it is not extraordinary, therefore, that evidence may be often strained from the writings of philosophers in support of prior claims to

* A most remarkable illustration of this fact occurs in the history of Locke, who certainly came as near to an important discovery as any philosopher who ever caught a glimpse of a truth without seizing it; but his statement did not, in any degree, hasten the developement of that new branch of science which was reserved for the genius of Dr. Black to investigate, and who a century later, by the discovery of fixed air, changed the whole face of Chemistry. The passage to which I allude is extracted from the Life by Lord King, and is so curious, that I shall give it a place in this note. "M. Toinard produced a large bottle of Muscat; it was clear when he set it on the table, but when he had drawn out the stopper, a multitude of little bubbles arose, and swelled the wine above the mouth of the bottle. It comes from this, that the air, which was included and disseminated in the liquor, had liberty to expand itself, and so to become visible, and being much lighter than the liquor, to mount with great quickness.—*Quere.* Whether this be air new generated, or whether the springy particles of air in the fruit, out of which these fermenting liquors are drawn, have, by the artifice of Nature, been pressed close together, and there by other particles fastened and held so;

late discoveries; but upon a candid review, these loose statements, or obscure hints, will generally be found wholly destitute of the pretensions which an unfair spirit of rivalry has too often laboured to support. Many of such hints, indeed, so far from advancing the progress of truth, had never even attracted notice, until after the discoveries to which they have been supposed to relate.

Although the importance of Davy's Electro-chemical discoveries could not for a moment be doubted; their claims to originality, it would seem, were not admitted without some question. The works of Ritter and Winterl, amongst many others, were quoted to shew that these philosophers had imagined or anticipated the relation between electrical powers and chemical affinities; but Davy very fairly observes, in a paper read before the Royal Society in 1826, that in the obscurity of the language and metaphysics of both those gentlemen, it is difficult to say what may not be found. In the ingenious though wild views of Ritter, there are hints which may more readily be considered as applying to *Electro-magnetism*, than to *Electro-chemistry;* while Winterl's *Miraculous Andronia* might, with as much propriety, be considered as a type of all the chemical substances that have been since discovered, as his view of the antagonist powers (the acid and base) be regarded as an anticipation of the *Electro-chemical* theory.

and whether fermentation does not loose these bands, and give them liberty to expand themselves again? Take a bottle of fermenting liquor, and tie a bladder on the mouth.—*Quere.* How much new air will it produce? and whether this has the quality of common air?"

Another instance equally illustrative of the manner in which important truths will sometimes elude notice, even after Science has approached so near as to touch them, is presented in the history of the Barometer. Toricelli, the pupil of Galileo, while reflecting upon the phenomenon which had so greatly perplexed his master, viz. that water could not be raised above thirty-two feet in the body of a pump, rightly conjectured that the water, under such circumstances, was not *drawn*, but *pushed up* into the barrel, and that it could only be so pushed up by the force of the atmosphere. It then occurred to him, that if mercury were used instead of water, being heavier, it would not be pushed up so high by the weight of the air. So, taking a glass tube of about three feet in height, made air-tight at one end, he first filled it completely with quicksilver, and then closing it with his finger, reversed it in a basin containing that metal, when he had the gratification of seeing the liquid in the tube descend, as he had anticipated. Here then was the discovery of the BAROMETER; but it was reserved for another to find out that such an instrument had been actually invented. Pascal first made the remark, that the inference of Toricelli, if true, might be confirmed by carrying the mercurial tube to a considerable elevation; when the atmospheric column being diminished, that of the mercury, which was supposed to be its balance, ought likewise to be shortened in a corresponding proportion. It followed then, that a measure of the weight of the atmosphere, in all circumstances, had been obtained, and consequently that of the height of any place to which the instrument could be carried. In this manner was a discovery completed, which had for ages escaped the greatest philosophers who had made the nearest approaches to its developement.

It would be worse than useless to speak of other works, which refer the origin of Electro-chemistry to Germany, Sweden, and France, rather than to Italy and England; and which attribute some of the views first developed by Davy, to philosophers who have not, nor ever could have made any claim of the kind, since their experiments were actually not published until many years after 1806, the date of the Bakerian Lecture.

With regard to the judgment of posterity upon these points, but little apprehension can be entertained. I well remember, in a conversation with Davy, he observed, that "a philosopher might generally discover how his labours would be appreciated in after ages, from the opinion entertained of them by contemporary foreigners, who, being unbiassed by circumstances of personality, will reduce every object to its just proportions and value."

If we acknowledge the truth of such a standard, and submit the posthumous fame of Davy to its measure, where is the philosopher, in our times, whose name is destined to attain a higher eminence in the history of science? Let the reader only recall to his recollection the bitter animosity which France and England mutually entertained towards each other in the year 1807, and he will be able to form some idea of the astounding impression which the Bakerian Lecture must have produced on the Savans of Paris, when, in despite of national prejudice and national vanity, it was crowned by the Institute of France with the prize of the First Consul! Thus did the Voltaic battery, in the hands of the English chemist, achieve what all the artillery of Britain could never have produced — A SPONTANEOUS AND WILLING HOMAGE TO BRITISH SUPERIORITY! — But let not this observation convey the slightest idea of disrespect, or be supposed to encourage any feeling to the disparagement of the chemists of France; on the contrary, it is even a question not readily answered, to which party the triumph fairly belongs, — to him who won the laurel crown, or to those who so nobly placed it on his brow? They have set an example to future ages, which may as materially advance the progress of science, as the researches which called it forth: —they have shown, to adopt the language of an eloquent writer, that "the Commonwealth of Science is of no party, and of no nation; that it is a pure Republic, and always at peace. Its shades are disturbed neither by domestic malice nor foreign levy; they resound not with the cries of faction or of public animosity. Falsehood is the only enemy their inhabitants denounce; Truth and her minister Reason, the only leaders they follow."

I shall avail myself of this opportunity to introduce the Report drawn up by M. Biot, and made in the name of a Commission appointed by the Institute to accomplish the intention of Bonaparte, who, when First Consul, founded prizes for important discoveries in Electricity or Galvanism.

It is an opinion very generally received, that despotism is hostile to the progress of Philosophy — that the suspicion natural to tyranny, and the fear that light should expose its deformity, have, under such circumstance, inspired a dread of any thing approaching to freedom of enquiry. The conduct of Napoleon, not only during his Consulate, but even after he had assumed the Purple, is in direct opposition to such an opinion. Now that the excitements of national hostility have subsided, and the asperity of our feelings towards that extraordinary man has been softened by time and prosperity, we are enabled to discern the bright and sunny spots in his character.

Not to mention the immense plans which his genius suggested for the internal improvement of France, the annals of the Institute would furnish innumerable proofs of the zeal with which he encouraged Science, and promoted its interests.

His liberation of Dolomieu from the dungeons of Tarentum was an act not only remarkable for the considerate regard it displayed for Science, but for the spirit and eagerness with which it was effected. The French government had repeatedly made the most urgent demands for the liberty of one who had reflected so much credit on his country ;—the Danes had also directed the interference of their Minister, and the King of Spain had added his solicitations in vain:—no sooner, however, had the astonishing campaign which terminated by the victory of Marengo, completely established the French Republic, than Bonaparte, in making peace with Naples, stipulated for the immediate deliverance of Dolomieu, as the first article of the treaty.

The following letter from Bonaparte, addressed to the Minister of the Interior, and by him transmitted to the Institute, expresses the intentions of the First Consul, in founding prizes for important discoveries in Electricity or Galvanism.

" I intend, Citizen Minister, to found a prize, consisting of a Medal of three thousand francs, (about one hundred and twenty pounds sterling,) for the best experiment which shall be made in the course of each year, on the Galvanic fluid.

" For this purpose, the Memoirs containing the details of the said experiments shall be sent before the First of *Fructidor*, to the class of the Mathematical and Physical Sciences, which in the complimentary days shall adjudge the prize to the author of that experiment which has been most useful to the progress of science.

"I also desire to give, by the way of encouragement, the sum of sixty thousand francs to the person who, by his experiments and discoveries, shall, according to the opinion of the Class, advance the knowledge of Electricity and Galvanism as much as Franklin and Volta did.*

"Foreigners of all nations are admitted to the competition.

"I beg you will make known these dispositions to the President of the First Class of the National Institute, that it may give to these ideas such developement as may appear proper; my particular object being to encourage philosophers, and to direct their attention to this part of philosophy, which, in my opinion, may lead to great discoveries.

(Signed) BONAPARTE."

Upon the presentation of this letter, a Committee was appointed to consider the means for accomplishing the intentions of the First Consul; and after expatiating upon the extensive agencies of Electricity, their Report concludes in the following manner:—

"To fulfil the intention of the First Consul, and to give to the competition all the solemnity which the importance of the object, the nature of the Prize, and the character of the Founder require, the Commissioners unanimously propose as follows:

"The Class of the Mathematical and Physical Sciences of the National Institute, opens the general competition required by the First Consul.

"All the learned of Europe, and the Members and Associates of the Institute, are admitted to the competition.

"The Class does not require that the Memoirs should be immediately addressed to it. Every year it will crown the author of the best experiments which shall come to its knowledge, and which shall have advanced the progress of the science.

* "À celui qui, par ses expériences et ses découvertes, *fera à faire à l'Electricité et au Galvanisme un pas comparable celui qu'ont fait faire à ces Sciences Franklin et Volta.*"

My French correspondent adds, "Ces soixantes mille francs n'ont pas été adjugés, *le pas n'ayant point été fait.*"

"The present report, containing the letter of the First Consul, shall be printed, and serve as a programme.

"Done at the National Institute, Messidor 11, year 10.

(Signed) LAPLACE, HALLE, COULOMB,
HAUY. BIOT, Reporter."

It was not until twelve months after the publication of his first Bakerian Lecture, that Davy received the intelligence that the prize of three thousand francs had been awarded him by the Institute of France, for his discoveries announced in the Philosophical Transactions for the year 1807.

Mr. Poole, in a late communication, informs me that he was in London soon after the letter, communicating this gratifying intelligence, had been received from France; and that Davy, upon shewing it to him, observed, "Some people say I ought not to accept this prize; and there have been foolish paragraphs in the papers to that effect; but if the two countries or governments are at war, the men of science are not. That would, indeed, be a civil war of the worst description; we should rather, through the instrumentality of men of science, soften the asperities of national hostility."

After Davy had been elected Secretary to the Royal Society, he appears to have been confined to town during the autumn of 1807, when he wrote the following letter.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, August 28th, 1807.

I AM obliged to be in the neighbourhood of town during the greater part of the summer, for the purpose of correcting the press for the Philosophical Transactions.

I made a rapid journey into Cornwall for the sake of seeing my family, and it was not in my power, had I received your letter at Lyme, to have accepted your kind invitation.

If C—— is still with you, will you be kind enough to say to him, that I wrote nearly a week ago two letters about lectures, and not knowing where he was, I addressed them to him at different places. I wish very much he would seriously determine on this point. The Managers of the Royal Institution are very anxious to engage him; and I think he might be of material service to the public, and of benefit to his own mind, to say nothing of the benefit his purse might also receive. In the present condition of society, his opinions in matters of taste, literature, and metaphysics, must have a healthy influence; and unless he soon become an actual member of the living world, he must expect to be hereafter brought to judgment 'for hiding his light.'

The times seem to me to be less dangerous, as to the immediate state of this country, than they were four years ago. The extension of the French Empire has weakened the disposeable force of France. Bonaparte seems to have abandoned the idea of invasion, and if our Government is active, we have little to dread from a maritime war, at least for some time. Sooner or later, our Colonial Empire must fall in due time, when it has answered its ends.

The wealth of our island must be diminished, but the strength of mind of the people cannot easily pass away; and our literature, our science, our arts, and the dignity of our nature, depend little upon our external relations. When we had fewer colonies than Genoa, we had Bacons and Shakspeares.

The wealth and prosperity of the country are only the *comeliness* of the body—the fulness of the flesh and fat;—but the spirit is independent of them; it requires only muscle, bone, and nerve, for the true exercise of its functions. We cannot lose our liberty, because we cannot cease to *think;* and ten millions of people are not easily annihilated. I am, my dear Poole,

Very truly yours,

H. Davy.

While the Electro-chemical laws, developed in the last chapter, are fresh in the recollection of the reader, I shall proceed to the consideration of his second Bakerian lecture, which was read in November 1807; and in which he announces the discovery of the metallic bases of the fixed alkalies,—a discovery immediately arising from the application of Voltaic electricity, directed in accordance with those laws; thus having, as we have seen in the first instance, ascended from particular phenomena to general principles, he now descends from those principles to the discovery of new phenomena; a method of investigation by which he may be said to have applied to his inductions the severest tests of truth, and to have produced a chain of evidence without having a single link deficient.

Since the account given by Newton of his first discoveries in Optics, it may be questioned whether so happy and successful an instance of philosophical induction has ever been afforded as that by which Davy discovered the composition of the fixed alkalies. Had it been true, as was most unjustly insinuated at the time, that the discovery was accidentally effected by the high power of the apparatus placed at his disposal, his claims to our admiration would have assumed a very different character; in such a case, he might be said to have forced open the sanctuary of Nature by direct violence, instead of having discovered and touched the secret spring by which its portals were unclosed. The justice of these remarks will best appear in the examination of his memoir: the highest eulogy that can be conferred on its author will be a faithful and plain history of its contents.

It will be remembered that, in his preceding lecture of 1806, he had described a number of decompositions and chemical changes produced in substances of known composition, by the powers of electricity, and that in all such cases there invariably subsisted an attraction between oxygen and the *positive* pole, and between inflammable matter and the *negative* pole of the pile: thus, in the decomposition of water, its oxygen was transferred to the former, and its hydrogen to the latter. Furnished with such data, Davy proceeded to submit a fixed alkali to the most intense action of the Voltaic apparatus, well convinced that, should the electrical energy be adequate to effect its decomposition, the elements would be transferred, according to this general law, to their respective poles.

His first attempts were made on solutions of the alkalies, but, notwithstanding the intensity of the electric action, the water alone underwent decomposition, and oxygen and hydrogen were disengaged with the production of much heat, and violent effervescence. The presence of water thus appearing to prevent the desired decomposition, potash, in a state of igneous fusion, was in various ways submitted to experiment; when it was evident that combustible matter of some kind, burning with a vivid light, was given off at the negative wire. After numerous trials, during the progress of which the difficulties which successively arose were as immediately combated by ingenious manipulation, a small piece of potash sufficiently moistened, by a short exposure to the air, to give its surface a conducting power, was placed on an insulated disc of platina, connected with the negative side of the battery in a state of intense activity, and a platina wire communicating with the positive side, was at the same instant brought into contact within the upper surface of the alkali.— Mark what followed! — A series of phenomena, each of which the reader will readily understand as it is announced,—for it will be in strict accordance with the laws which Davy had previously established: the potash began to fuse at both its points of electrization; a violent effervescence commenced at the upper, or positive surface, while at the lower, or negative one, instead of any liberation of elastic matter, which would probably have happened had hydrogen been an element of the alkaline body, small globules, resembling quicksilver, appeared, some of which were no sooner formed than they burnt with explosion and bright flame.—What must have been the sensations of Davy at this moment!—He had decomposed potash, and obtained its base in a metallic form.

The gaseous matter developed, during the experiment, at the positive pole of the apparatus, he very shortly identified as oxygen. To collect, however, the metallic matter, in a quantity sufficient for a satisfactory examination, was by no means so easy; for, like the *Alkahest* imagined by the Alchemist, it acted more or less upon every body to which it was exposed; and such was its attraction for oxygen, that it speedily reverted to the state of alkali by recombining with it.

After various trials, however, it was found that recently distilled naphtha presented a medium in which it might be preserved and examined, since a thin transparent film of this fluid, while it defended the metal from the action of the atmosphere, did not oppose any obstacle to the investigation of its physical properties.

Thus provided, he proceeded to enquire into the nature of the new and singular body, to which he afterwards gave the name of Potassium, and which may be described as follows.

Its external character is that of a white metal, instantly tarnishing by exposure to air; at the temperature of 70° Fah. it exists in small globules, which possess the metallic lustre, opacity, and general appearance of quicksilver; so that when a globule of the latter is placed near one of the former, the eye cannot discover any difference between them; at this temperature, however, the metal is not perfectly fluid; but when gradually heated, it becomes more so,—and at 150°, its fluidity is so perfect that several globules may be easily made to run into one. By reducing its temperature, it becomes, at 50°, a soft and malleable solid, which has the lustre of polished silver, and is soft enough to be moulded like wax. At about the freezing point of water it becomes hard and brittle, and exhibits, when broken, a crystallized structure of perfect whiteness, and of high metallic splendour. It is, also, a perfect conductor both of electricity and heat. Thus far, then, it fulfils every condition of a metal; but an anomaly of a most startling description has now to be mentioned—the absence of a quality which has been as invariably associated with the idea of a metal, as that of lustre, viz. great specific gravity. Whence a question has arisen, whether, after all, the alkaline base can with propriety be classed under that denomination? Instead of possessing that ponderosity which we should have expected in a body otherwise metallic, it is so light as not only to swim upon the surface of water, but even upon that of naphtha, by far the lightest liquid in nature. Davy, however, very justly argues, that low specific gravity does not offer a sufficient reason for degrading this body from the rank of a metal; for amongst those which constitute the class, there are remarkable differences with respect to this quality, that platina is nearly four times as heavy as tellurium. In the philosophical division of bodies into classes, the analogy between the greater number of properties must always be the foundation of arrangement.*

So inseparable however, by long association, are the ideas of ponderosity and metallic splendour, that the evidence even of the senses may fail in disuniting them.† This is well illustrated by the following amusing anecdote. Shortly after the discovery of potassium, Dr. George Pearson happened to enter the laboratory in the Royal Institution, and upon being shewn the new substance, and interrogated as to its nature, he, without the least hesitation, on seeing its lustre, exclaimed, "Why, it is metallic, to be sure," and then, balancing it on his finger, he added, in the same tone of confidence, "*bless me, how heavy it is!*"

When thrown upon water, potassium instantly decomposes that fluid, and an explosion is produced with a vehement flame; an experiment which is

* The propriety, and even the necessity of such a compact become daily more apparent, as our knowledge of bodies extends. If we were to degrade a substance from its class, in consequence of the absence of some one quality which enters into its more perfect examples, we should soon find ourselves involved in paradoxes.—What idea, for instance, could we form of an acid—its sourness?—Prussic Acid—Arsenious Acid, are not sour.—Its tendency to combine with an alkaline or earthy base?—If so, sugar is an acid, for it combines with lime. I remember a chemist having been exposed to much ridicule from speaking of a *sweet* acid—Why not?

† In the language of Darwin, we should say, that the simple ideas of weight and lustre, which form the complex idea of a metal, have become so indissoluble, that they can no longer be separated by volition. The principle admits of many familiar illustrations, and is the source of numerous fallacies. When any one voluntarily recollects a Gothic window, which he had seen some time before, the whole front of the Cathedral occurs to him at the same time: in like manner, the taste of a pine-apple, though we eat it blindfold, recalls the colour and shape of it. Coleridge has made a good remark upon this subject. He says, "It is a great law of the imagination, that a likeness in part tends to become a likeness of the whole." It is thus that we trace images in the fire, castles in the clouds, and spectres in the gloom of twilight.

rendered more striking if, for water, ice be substituted; in this latter case, it instantly burns with a bright rose-coloured flame, and a deep hole is made in the ice, which will afterwards be found to contain a solution of potash.

It is scarcely necessary to state, that these phenomena depend upon the very powerful affinity which the metal possesses for oxygen, enabling it even to separate it from its most subtle combinations.*

One of the neatest modes of shewing the production of alkali, in the decomposition of water by the basis of potash, consists in dropping a globule of potassium upon moistened paper tinged with turmeric. At the moment that it comes into contact with the water, it burns and moves rapidly upon the paper, as if in search of moisture, leaving behind it a deep reddish-brown trace of its progress, and acting upon the test paper precisely as dry caustic potash.

From these observations, the reader will immediately perceive, that the decomposition of the fixed alkalies has placed in the hands of the experimentalist a new instrument of research, scarcely less energetic, or of less universal application, than the power from which the discovery emanated. Davy observes upon this point, that "it will undoubtedly prove a powerful agent for analysis, and having an affinity for oxygen, stronger than any other known substance, it may possibly supersede the application of electricity to some of the undecompounded bodies." So strong indeed is its affinity for oxygen, that it discovers and decomposes the small quantities of water contained in alcohol and ether; and in the latter case, this decomposition is connected with an instructive result. Potash is insoluble in that fluid: when therefore its base is thrown into it, oxygen is furnished, hydrogen gas disengaged, and the alkali, as it is regenerated, renders the ether white and turbid.

* If we are disposed to enter into a more critical examination of the subject, we shall find that, although the above is a general expression of the change produced, there are subordinate actions of a more complicated nature: the metal, in the first place, decomposes a portion of the water, in order to combine with its oxygen, and form potash, which in its turn has a powerful affinity for water; the heat arising from two causes, decomposition and combination, is sufficiently intense to produce the inflammation. Water is a bad conductor of heat; the globule swims exposed to air; a part of which is dissolved by the heated nascent hydrogen; and this gas, being capable of spontaneous inflammation, explodes and communicates the effect of combustion to any of the bases that may be yet uncombined. The manner in which the potassium runs along the surface of water may be compared to a drop of water on red-hot iron; in the one case the hot potassium, in the other the cold water, is enveloped in an atmosphere of steam.

But perhaps the most beautiful illustration of its deoxidizing power is afforded by its action on carbonic acid gas, or fixed air: when heated in contact with that gas, it catches fire, and by uniting with its oxygen, becomes potash, while the liberated carbon is deposited in the form of charcoal.

As I have already exceeded the limits originally prescribed to myself, I shall not enter into the history of Davy's experiments on the other fixed alkali, soda, farther than to state that, when it was submitted to Voltaic action, a bright metal was obtained, similar in its general characters to potassium, but possessing sufficiently distinctive peculiarities as to volatility, fusibility, oxidability, &c. To this body Davy assigned the name of SODIUM.*

In support of the metallic characters of these alkaline bases, it may be necessary to state that they combine with each other, and form alloys; the properties and habitudes of which are very interesting, and are fully described by their discoverer.

No sooner had these results been made known to the scientific world, than a question arose, both in this country and abroad, as to the real nature of the bodies which had been thus obtained from the fixed alkalies, and which presented an aspect so obviously metallic. At first, it was conjectured by a few, that they might be compounds of the alkali with the platina used in the experiments; but this was at once disproved by Davy having obtained the same results when pieces of copper, silver, gold, plumbago, or even charcoal, had been employed for completing the Voltaic circuit.

The effect which this and his subsequent discoveries produced, in revolutionizing the theory of Chemistry, will form an interesting subject for discussion in a future part of the present work; I shall therefore only remark in passing, that the fact of oxygen, the acknowledged principle of acidity, existing in combination with a metallic base, and imparting to it the properties of an alkali, was no sooner announced, than its truth was strenuously denied. It was an attack upon opinions sanctioned by the general suffrage of the scientific world; it was, in fact, storming the very citadel of their philosophy; no wonder, then, that the agitator should have been assailed with a full cry for his revolutionary plans.† M. Curadau read a paper before the

* In his Bakerian Lecture of 1810, he informs us that he obtains Sodium by heating common salt, which has been previously ignited, with Potassium—an immediate decomposition takes place, and two parts of Potassium produce rather more than one of Sodium.

† Many years afterwards, when Davy was travelling on the Continent, a distinguished person about a foreign court, enquired who and what he was; never having heard of his scientific fame;

French Institute, in which he endeavoured to prove, *first*, that the conversion of the alkalies into metals was not a deoxidation of those bodies, but a combination of them with new elements;—*secondly*, that the affinity of the alkaline metals for oxygen was merely a chemical illusion, occasioned by some body the presence of which had not been suspected;—*thirdly*, that carbon was one of the elements of the alkaline metals, since it could be separated from them at pleasure, or converted into carbonic acid;—and *fourthly*, that if the specific gravities of the new substances were less than that of water, it was because hydrogen was associated with carbon in the combination.

It is scarcely necessary to state, that the presence of carbon was readily traced to sources of impurity. The hypothesis which assumed the existence of hydrogen as an element, was not so easily refuted. It was espoused by M. M. Gay Lussac, Thenard, and Ritter, on the Continent, and by Mr. Dalton in England. The former derived their inference from the action of potassium upon ammonia, by which they obtained a fusible substance that yielded by heat more hydrogen than the ammonia contained; the latter contended that potassium and sodium are proved to be *hydrurets*, by the very process employed for their production; for, since common potash is a *hydrat*, and oxygen is produced at one surface, and potassium at the other, by Voltaic action, he conceived that the former arose from the decomposition of water, and that the hydrogen must therefore unite with the potash to form potassium. It is a curious fact, that Berthollet, in the very sentence in which he insisted upon the excessive quantity of hydrogen disengaged in his experiment, as a proof that potassium must be a *hydruret*, should have stated that the addition of water to the residuum was necessary for obtaining his result. How could it have happened that he overlooked so obvious a source of hydrogen? Mr. Dalton, as well as Ritter, considered the low specific gravity as favouring the idea of their containing hydrogen; but Davy observes that they are less volatile than antimony, arsenic, and tellurium, and much less so than mercury. Besides, sodium absorbs much more oxygen then potassium, and on the hypothesis of hydrogenation, must therefore contain more hydrogen; and yet though soda is said to be lighter than potash, in the proportion of thirteen to seventeen nearly, yet sodium is

upon being told that his discoveries had revolutionized Chemistry, the courtier promptly replied—" I hate all revolutionists—his presence will not be acceptable here."

heavier than potassium, in the proportion of nine to seven at least. On the theory of Davy, this circumstance is what ought to have been expected. Potassium has a much stronger affinity for oxygen than sodium, and must condense it much more; and the resulting higher specific gravity of the combination is a necessary consequence. In this manner did Davy entangle his opponents in their own arguments, and establish, in the most triumphant manner, the truths of his original views.

Thus then was a discovery effected, and at once rendered complete, which all the chemists in Europe had vainly attempted to accomplish. The alkalies had been tortured by every variety of experiment which ingenuity could suggest, or perseverance perform, but all in vain; nor was the pursuit abandoned until indefatigable effort had wrecked the patience and exhausted every resource of the experimentalist. Such was the disheartening, and almost forlorn condition of the philosopher when Davy entered the field:—he created new instruments, new powers, and fresh resources; and Nature, thus interrogated on a different plan, at once revealed her long cherished secret.

In his Bakerian Lecture, Davy observes, that "a historical detail of the progress of the investigation of all the difficulties that occurred, and of the manner in which they were overcome, and of all the manipulations employed, would far exceed the limits assigned to a Lecture." But to the chemist, every circumstance, however minute, connected with a subject of such commanding importance, is pregnant with interest; I therefore considered it my duty to search into the archives of the Institution, in the hope that I should discover some memoranda which might supply additional information. In examining the Laboratory Register, I have so far succeeded as to obtain some rough and imperfect notes, which will, to a certain degree, assist us in analysing the intellectual operations by which his mind ultimately arrived at the grand conclusion.

It appears from this register, that Davy commenced his enquiries into the composition of potash on the 16th, and obtained his great result on the 19th of October 1807. His first experiments, however, evidently did not suggest the truth; he does not appear to have suspected the nature of the alkaline base until his last experiment, when the truth flashed upon him in the full blaze of discovery. His first note, dated the 16th, leads us to infer that he acted on a solid piece of potash, under the surface of alcohol, and several other liquids in which the alkali was not soluble; and that he obtained gaseous

Oct^r. 19^th

When Potash was introduced into a tube ⊕ having a platina wire attached to it so & fused into the tube so as to be a conductor i.e. so as to contain

just water enough slightly soluted — — & inverted over mercury, when y^e Platina was made neg — No gas was formed & the mercury became oxydated — & a small quantity of the alkalizer was produced round the Plat: wire as was evident from its going into inflammation by the action of water — When the mercury was made the neg: gas was develop: in great quantities from the pos: wire ~~[struck out]~~ gas & none from the neg mercury & this gas proved to be pure oxygene i.e. Cap^l: Exp^t.

proving the decomp^n of Potash

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matter, which he called at the moment, '*Alkaligen Gas*,' and which he appears to have examined most closely, without arriving at any conclusion as to its nature. On the following day, he, for the first time, would seem to have developed potassium by electric action on potash under oil of turpentine, for the note records the fact of "*the* globules giving out gas by water, which gas *burnt in contact with air*;" and then follows a query—"Does *it*" (the matter of the globules) "not form gaseous compounds with ether, alcohol, and the oils?" Here then he evidently imagined, that the matter of the globules, which he had never obtained from potash, except when acted upon under oil of turpentine, had formed gaseous compounds with the ether, alcohol, and oils in his previous experiments, and given origin to that which he had termed '*Alkaligen Gas*.'

He then leaves the consideration of this gas, and attacks the unknown globules, which probably did not present any metallic appearance under the circumstances he saw them, for they must have been as minute as grains of sand. I rather think that he commenced his examination by introducing a globule of mercury, and uniting it with a globule of the unknown substance, for his note says, "Action of the substance on Mercury,—forms with it a solid amalgam, which soon loses its *Alkaligen* in the air." And from the note which succeeds, he evidently considered this *Alkaligen* (potassium) volatile, as he says "it soon flies off on exposure to the air."

October 19.—It is probable that, in consequence of the property which the unknown substance displayed of amalgamating with mercury, he devised his experiment of the 19th. He took a small glass tube, about the size and shape of a thimble, into which he fused a platinum wire, and passed it through the closed end. He then put a piece of pure potash into this tube, and fused it into a mass about the wire, so as entirely to defend it from the mercury afterwards to be used. When cold, the potash was solid, but containing moisture enough to give it a conducting power; he then filled the rest of the tube with mercury, and inverted it over the trough: the apparatus being thus arranged, he made the wire and the mercury alternately positive and negative;—and now, conceiving that I have sufficiently explained his brief notes, the reader shall receive the result in his own words; for this purpose I have obtained an engraving of the autograph, which is here annexed. On the same day, he decomposed soda with somewhat different phenomena.

From this same Register, it appears that, in the preceding month, he was deeply engaged in experiments on '*Antwerp blue*,' which he found to consist of *Prussiate of Iron* and *Alumina*, "probably in the proportion of two-thirds of the former to one-third of the latter."

On the 6th of October, we learn from the same source, that he performed a beautiful experiment, that of producing the vegetation of the carbon of the wick of a candle, by placing it between the wires of the battery.

On the 12th of the preceding September he addressed a letter to Mr. Gilbert, which is curious, as it shews that very nearly up to the time of the decomposition of the alkalies, his mind had been engaged on very different subjects.

TO DAVIES GIDDY, ESQ.

MY DEAR SIR, September 12, 1807.

I INCLOSE Mr. Carne's paper, which, when you have read, and Mr. Carne revised, I will thank you to inclose to me, and that as soon as possible, for the completion of the volume.

I have been a good deal engaged, since my return, in experiments on distillation, and I have succeeded in effecting what is considered of great importance in colonial commerce, namely, the depriving rum of its empyreumatic part, and converting it into pure spirit.

I mention this in confidence, as it is likely to be connected with some profitable results; and it may be beneficial in a public point of view, by lessening the consumption of malt.

I have heard of no scientific news; this, indeed, is little the season for active exertion.

With best respects to your father, and to Mr. and Mrs. Guillemard,

I am, my dear Sir,

Always very faithfully yours,

H. DAVY.

Few notes have conveyed information of such importance to the scientific world, as that which follows, announcing, at the same time, the decomposition of the fixed alkalies, and the formation of the Geological Society, of which it would thus appear that Davy was one of the founders.

TO WILLIAM HASLEDINE PEPYS, ESQ.

DEAR PEPYS, November 13, 1807.

If you and Allen had been one person, the Council of the Royal Society would have voted to you the Copleian Medal;* but it is an indivisible thing, and cannot be given to two.

We are forming a little talking geological Dinner Club, of which I hope you will be a member. I shall propose you to-day. Some things have happened in the Chemical Club, which I think render it a less desirable meeting than usual, and I do not think you would find any gratification in being a member of it. Hatchett never comes, and we sometimes meet only two or three. I hope to see you soon.

I have decomposed, and recomposed the fixed alkalies, and discovered their bases to be two new inflammable substances very like metals; but one of them lighter than ether, and infinitely combustible. So that there are two bodies decomposed, and two new elementary bodies found.

Most sincerely yours, H. Davy.

In the year 1808, M. M. Gay Lussac and Thenard succeeded in decomposing potash by chemical means; for which purpose it is only necessary to heat iron turnings to whiteness in a curved gun-barrel, and then to bring melted potash slowly in contact with the turnings, air being excluded; when the iron, at that high temperature, will take the oxygen from the alkali, and the potassium may be collected in a cool part of the tube. It may likewise be produced by igniting potash with charcoal, as M. Curaudau shewed in the same year.

In the following letter Davy gives an account of his repeating the experiment of M. M. Gay Lussac and Thenard; mixing together, as usual, science and angling.

TO J. G. CHILDREN, ESQ.

MY DEAR SIR, London, July 1808.

I have this moment received your kind letter, and I have written to Pepys to propose to him to be with you on Sunday or Monday. I hope for his answer to-morrow morning, and I will write to you immediately.

* He alludes to a Paper, entitled "On the Quantity of Carbon in Carbonic Acid, and on the Nature of the Diamond; by William Allen, Esq. F.R.S. and William Hasledine Pepys, Esq." Communicated by Humphry Davy, Sec. R.S. M.R.I.A. Read June 16, 1807.

I will procure all the fishing tackle you have proposed, and am most happy to find you in so determined a spirit for piscatory adventure.

I have had some letters from France; but nothing new, except an account of the gun-barrel experiment tolerably minute. I have tried it since, and procured potassium, but it was lost from some moisture passing into the aperture of the barrel. All that is necessary for the process is a gun-barrel bent thus, B  A.—— B represents the part where the touch-hole is closed, here dry potash is introduced, and the middle, which is to be strongly ignited, contains the filings, the potash is gradually fused and made to run down upon the ignited iron; the potassium collects in A.

If you should be able to procure the apparatus for this experiment, I should like to assist in repeating it; and could we procure a large quantity of the basis, we may try its effects, on a great scale, on the undecompounded acids. I will bring some *dry boracic acid.* A copper or platina tube, if you have one, will be proper for trying the experiment in. We may likewise try its action upon the earths, and upon diamond.

I have metallized Ammonia,* without the application of Electricity. When an amalgam of potassium and mercury are brought in contact with an ammoniacal salt, the potassium seizes upon the oxygen, and the hydrogen and nitrogen unite to the quicksilver.

I had an opportunity of giving an account, on Friday, to the scientific men assembled at Greenwich, of your magnificent experiments and apparatus.† Sir Joseph Banks, Mr. Cavendish, Wollaston, &c. all expressed a strong wish that the results should be published. I am most happy you have drawn up the account.

* He here alludes to a train of research, which will be considered hereafter.

† This observation relates to the magnificent battery constructed by Mr. Children, of which he presented an account to the Royal Society, in a Paper read in November 1808, entitled, "An Account of some Experiments, performed with a view to ascertain the most advantageous Method of constructing a Voltaic Apparatus, for the purpose of Chemical Research. By John George Children, Esq. F.R.S." The great battery described in this Paper consisted of twenty pairs of plates, each plate being four feet high by two feet wide: the sum of all the surfaces was ninety-two thousand one hundred and sixty square inches, and the quantity of liquid necessary for charging it, one hundred and twenty gallons. At the same time he constructed another battery, which consisted of two hundred pairs of plates, each being only two inches square. In the one case, then, he commanded extent of surface, in the other, extent of number; and by a series of comparative experiments he fully established the theory of Davy (page 158), that the *intensity* of Electricity increases with the *number*, and the *quantity* with the *surface*.

I regard the days I have passed in your society, as some of the pleasantest of my life. I look forward with a warm hope to our next meeting. Be pleased to assure your father of my highest respect, and of my gratitude for his kindness.

I am, my dear Sir,

Very sincerely yours,

H. Davy.

It is impossible to reflect upon the chemical processes by which potassium may be obtained, without feeling surprised that the discovery should not have long before been accomplished. It is evident that the substance must have been repeatedly developed during the operations of chemistry; alkalies had been frequently heated to whiteness in contact both with iron and charcoal, and in some instances the appearance of a highly combustible body, which could have been no other than potassium, had even been observed as a result of the process, and yet no suspicion, as to its real nature, ever crossed the mind of the experimentalist; he satisfied himself with designating such a product, whenever it occurred, by the term *Pyrophorus*. I remember the late Mr. William Gregor informing me that, in the course of his analytical experiments with potash and different metals, he had repeatedly observed a combustion on removing the crucible from the furnace, and exposing its contents, which he could never understand. How admirably do such anecdotes illustrate the remark made in the commencement of the present chapter, that truth may be often touched, but is rarely caught, in the dark.

The facility of the combustion of the bases of the alkalies, and the readiness with which they decomposed water, offered Davy the ready means for determining the proportions of their constituent parts; and in comparing all his results, he thinks that it will be a good approximation to the truth, to consider potash as composed of about six parts base and one of oxygen; and soda, as consisting of seven base and two of oxygen.

The discovery of potassium led to that of the true nature of what had been long familiar to chemists by the name of *pure Potash*, but which ought to have been called the *hydrat*, for the *pure* alkali was not known until after the discovery of Davy. The experiments of M. M. Gay Lussac and Thenard have shown this substance to be a *Protoxide*. It is difficult of fusion; it has a grey colour and a vitreous fracture, and dissolves in water with much heat. The *Peroxide* is procured by the combustion of potassium at a low temperature; it had been observed by Davy in October 1807, but at that time he supposed it to be the oxide containing the smallest proportion of oxygen: it has a yellow colour, and when thrown into water effervesces, and gives out oxygen gas.* When heated very strongly upon platina, oxygen is also expelled from it, and there remains the *protoxide*, or pure potash.

It was a great object with Davy, to show that the product resulting from the combustion of potassium, was a pure oxide free from water; for it is evident that had potassium been a *Hydruret*, its combustion must have produced a *Hydrat*. This he accomplished by a series of experiments which he performed in the laboratory of Mr. Children, and which are published in his Bakerian Lecture of 1800.

Having discovered the presence of oxygen in the fixed alkalies, he was naturally led by analogy to inquire whether ammonia might not also contain it. It was true that the chemical composition of that body had been considered as satisfactorily settled, and that the conversion of it into hydrogen and nitrogen, in the experiments of Scheele, Priestley, and Berthollet, had left nothing farther to be accomplished. All new facts, however, are necessarily accompanied by a new train of analogies; and Davy, in perusing the accounts of the various experiments to which ammonia had been submitted, tells us that he saw no reason for considering the presence of oxygen as impossible; for, supposing hydrogen and nitrogen to exist in combination with oxygen in low proportion, this latter principle might easily disappear in the analytical experiments by heat and electricity, in the form of water deposited upon the vessels employed, or dissolved in the gases produced.

Under this impression, he commenced a series of experiments by which, he says, he soon became satisfied of the existence of oxygen in the volatile alkali. By means of the Voltaic battery, he ignited perfectly dry charcoal in a small quantity of pure ammoniacal gas, and he produced carbonate of ammonia; which could not have happened, had not oxygen been furnished by the volatile alkali to the carbon. In the next place, by an ingenious arrangement of apparatus, he submitted ammonia to a high temperature, and effected its decomposition, when a quantity of water appeared as one of the products. It will be useless to enter into farther details upon this occasion, as we shall pre-

* The 'Potassa Fusa' of our Pharmacopœia generally contains a small proportion of the peroxide, and will therefore effervesce when thrown into water.

sently perceive the subject assumed a different aspect, and led the experimentalist into a new line of inquiry.

At the conclusion of his Bakerian Lecture of 1807, he speaks of the probable composition of the earths, and considers it reasonable to expect that they are compounds of a similar nature to the fixed alkalies—"peculiar highly combustible metallic bases united to oxygen;"—but, as yet, this theory was sanctioned only by strong analogies; it was his good fortune, at a subsequent period, to support it by conclusive facts.

When the importance and novelty of the results he obtained from the fixed alkalies, and their influence upon the reigning theories, are duly considered, it may be easily imagined how intense was the curiosity to witness the production of the new metals, to examine their singular qualities, and to question the illustrious discoverer upon their nature and relations. Suppose it were publicly announced that one of the greatest Astronomers of the day had invented a telescope of new and extraordinary powers; and that by its means a hitherto unsuspected system of heavenly bodies might be seen, the character and motions of which were wholly inconsistent with the Newtonian theory of the universe. The surprise and eager curiosity which such an announcement would create might possibly be more general, because a knowledge of Astronomy is more widely diffused than that of Chemistry; but the sensation would not be more intense than that which the discovery of potassium produced. The laboratory of the Institution was crowded with persons of every rank and description; and Davy, as may be readily supposed, was kept in a continued state of excitement throughout the day. This circumstance, co-operating with the effects of the fatigue he had previously undergone, produced a most severe fit of illness, which for a time caused an awful pause in his researches, broke the thread of his pursuits, and turned his reflections into different channels.

He always laboured under the impression that the fever had been occasioned by contagion, to which he had been exposed in one of the jails during an experiment for fumigating it. This impression appears to have continued through life, for in his "last days" he alludes to it in terms of strong conviction.

Other persons referred his illness to the deleterious fumes, especially those of Baryta, to which his experiments had exposed him; an opinion recorded in an Epigram,* which was circulated amongst the members of the Institution after his recovery.

Says Davy to Baryt, "I 've a strong inclination
To try to effect your deoxidation;"
But Baryt replies—"Have a care of your mirth,
Lest I should retaliate, and change *you* to Earth."

Upon conversing, however, with Dr. Babington, who, with Dr. Frank, attended Davy throughout this illness, he assured me that there was not the slightest ground for either of these opinions; that the fever was evidently the effect of fatigue and an over-excited brain. The reader will not feel much hesitation in believing this statement, when he is made acquainted with the habits of Davy at this period. His intellectual exertions were of the most injurious kind, and yet, unlike the philosophers of old, he sought not to fortify himself by habits of temperance. Should any of my readers propose to me the same question respecting Davy, as Fontenelle tells us was put to an Englishman in Paris, by a scientific Marquis, with regard to Newton,—whether he ate, drank, and slept like other people?—I certainly should be bound to answer in the negative.

Such was his great celebrity at this period of his career, that persons of the highest rank contended for the honour of his company at dinner, and he did not possess sufficient resolution to resist the gratification thus afforded, although it generally happened that his pursuits in the laboratory were not suspended until the appointed dinner-hour had passed. On his return in the evening, he resumed his chemical labours, and commonly continued them till three or four o'clock in the morning; and yet the servants of the establishment not unfrequently found that he had risen before them. The greatest of all his wants was Time, and the expedients by which he economised it often placed him in very ridiculous positions, and gave rise to habits of the most eccentric description: driven to an extremity, he would in his haste put on fresh linen, without removing that which was underneath; and, singular as the fact may appear, he has been known, after the fashion of the grave-digger in Hamlet, to wear no less than five shirts, and as many pair of stockings, at the same time.

* I have reason to think that this *jeu d'esprit* was from the pen of the late learned Orientalist, Mr. Stephen Weston; a copy of which he was so kind as to send me only four days before his death.

Exclamations of surprise very frequently escaped from his friends at the rapid manner in which he increased and declined in corpulence.

At the commencement of his severe illness in November 1807, he was immediately attended by Dr. Babington and Dr. Frank; and upon its assuming a more serious aspect, these gentlemen were assisted by Dr. Baillie. Such was the alarming state of the patient, that for many weeks his physicians regularly visited him four times in the day, and issued bulletins for the information of the numerous enquirers who anxiously crowded the hall of the Institution. His kind and amiable qualities had secured the attachment of all the officers and servants of the establishment, and they eagerly anticipated every want his situation might require. The housekeeper, Mrs. Greenwood, watched over him with all the care and solicitude of a parent; and, with the exception of a single night, never retired to her bed for the period of eleven weeks. In the latter stage of his illness, he was reduced to the extreme of weakness, and his mind participated in the debility of the body. It may not perhaps be thought philosophical to deduce any inference, as to character, from traits which are displayed under such circumstances; I have little doubt, however, but that the mind, like inorganic matter, will, in its decay, frequently develope important elements, which under other conditions were not distinguishable. Suppose pride and timidity to exist as qualities in the same mind, the former might so far predominate as to enable its possessor to face the cannon's mouth; but diminish its force by moral or physical agency, the natural timidity will gain the ascendency, and the hero be converted into a coward. Such are my reasons for introducing the following anecdote: I would not give to it a greater value than it deserves, but it surely demonstrates the existence of kindly affections. Youthful reminiscences, and circumstances connected with his family and friends, were the only objects which, at this period, occupied his thoughts, and afforded him any pleasure. No Swiss peasant ever sighed more deeply for his native mountains, than did Davy for the scenes of his early years. He entreated his nurse to convey to his friends his ardent wish to obtain some apples from a particular tree which he had planted when a boy; and, unlike Locke with his cherries, he had no power of controlling the desire by his reason, but remained in a state of restlessness and impatience until their arrival: at the same time, he expressed a wish to obtain several other objects, especially an ancient tea-pot, endeared to him by early associations.

The following Minute appears on the Journals of the Institution:—

"December 7, 1807.—Mr. Davy having been confined to his bed for the last fortnight by a severe illness, the Managers are under the painful necessity of giving notice, that the Lectures will not commence until the first week in January next."

The Course was, at the time stated, opened by the Reverend Mr. (now Dr.) Dibdin; and his introductory lecture was, by order of the Managers, printed "for the satisfaction of those proprietors who were not present." It thus commences:—"Before I solicit your attention to the opening of those lectures which I shall have the honour of delivering in the course of the season, permit me to trespass upon it for a few minutes, by stating the peculiar circumstances under which this Institution is again opened; and how it comes to pass that it has fallen to me, rather than to a more deserving lecturer, to be the first to address you.

"The Managers have requested me to impart to you that intelligence, which no one who is alive to the best feelings of human nature can hear without mixed emotions of sorrow and delight.

"Mr. Davy, whose frequent and powerful addresses from this place, supported by his ingenious experiments, have been so long and so well known to you, has for these last five weeks been struggling between life and death;—the effects of those experiments recently made in illustration of his splendid discoveries, added to consequent bodily weakness, brought on a fever so violent as to threaten the extinction of life. Over him, it might emphatically be said in the language of our immortal Milton, that

———' Death his dart
Shook, but delayed to strike.'

Had it pleased Providence to have deprived the world of any further benefit from his original talents, and immense application, there certainly has been already enough effected by him to entitle his name to a place amongst the brightest scientific luminaries of his country. That this may not appear an unfounded eulogium, I shall proceed, at the particular request of the Managers, to give you an outline of the splendid discoveries to which I have just alluded; and I do so with the greater pleasure, as that outline has been drawn in a very masterly manner by a gentleman of all others perhaps the best qualified to do it effectually."

The Lecturer then proceeded to take a general and rapid view of his labours, which it is unnecessary to introduce in this place, and concluded as follows:—

"This recital will be sufficient to convince those who have heard it of the celebrity which the author of such discoveries has a right to attach to himself; and yet no one, I am confident, has less inclination to challenge it. To us, and to every enlightened Englishman, it will be a matter of just congratulation, that the country which has produced the two Bacons and Boyle, has in these latter days shown itself worthy of its former renown by the labours of Cavendish and Davy. The illness of the latter, severe as it has been, is now abating, and we may reasonably hope that the period of convalescence is not very remote."

Fortunately for the cause of Science—fortunately for the interests of the Institution, the prediction of the learned Lecturer was shortly verified.

The Institution indeed had already suffered from the calamity; for, in a Report to the Visitors, dated January 25, 1808, it is stated, that "there has been an excess of expenditure beyond the receipts. Among the causes of diminished income may be mentioned the postponement of the lectures, in consequence of the lamented illness of the excellent Professor of Chemistry; and among the items of increased expenditure, the extra expense of the Laboratory, in which have been produced Mr. Davy's recent discoveries, so honourable to the Royal Institution, and so beneficial to the interests of science in every part of the world."

This Report is succeeded by the following Minute:—

"February 22, 1808.—Mr. Davy attended at the request of the Committee, and informed them that he should be able to commence his course of Lectures on Electro-chemical science on Saturday the 12th of March, at two o'clock; and those on Geology on Wednesday evening, the 16th of that month."

The following letter to Mr. Poole announces the restoration of his health, and communicates some other circumstances of interest. Mr. Poole, it would appear, entertained doubts as to whether Davy received the prize of France for his first or second Bakerian Lecture, upon which point this letter sets him right.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, March, 1808.

Many thanks for your kind letter. I have seen your friend Mr. B—— for a minute, and, to use a geological term, I like his *aspect*, and shall endeavour to cultivate his acquaintance.

I am exceedingly busy; my health is re-established; and I am entering again into the career of experiment.

The prize which you congratulate me upon was given for my paper of 1806, and not for my last discoveries, which will probably excite more interest.

C——, after disappointing his audience twice from illness, is announced to lecture again this week. He has suffered greatly from excessive sensibility —the disease of genius. His mind is as a wilderness, in which the cedar and the oak, which might aspire to the skies, are stunted in their growth by underwood, thorns, briars, and parasitical plants. With the most exalted genius, enlarged views, sensitive heart, and enlightened mind, he will be the victim of want of order, precision, and regularity. I cannot think of him without experiencing the mingled feelings of admiration, regard, and pity.

Why do you not come to London? Many would be happy to see you; but no one more so than your very sincere friend, my dear Poole,

H. Davy.

It is difficult to convey an adequate idea of the universal interest which was excited by the lectures on Electro-chemical Science, to which an allusion has been just made. The Theatre of the Institution overflowed; and each succeeding lecture increased the number of candidates for admission.

It is unnecessary, after what has been already stated, to describe the masterly style in which he demonstrated and explained those general laws which his genius had developed, or to enumerate the beautiful and diversified experiments by which he illustrated their application, in simplifying the more complex forms of matter.

His evening lectures on Geology were equally attractive; and by a method as novel as it was beautiful, he exhibited, by the aid of transparencies, the structure of mountains, the stratification of rocks, and the arrangements of mineral veins.

The Easter recess afforded him a few days of leisure, which from the following note he appears to have devoted to his favourite amusement.

TO W. H. PEPYS, ESQ.

MY DEAR PEPYS, April, 1808.

Children has had the kindness to arrange our party, and we are to meet him, at all events, on Tuesday at two o'clock, at Foot's Cray.

I have proposed that we should leave town at about five or six on Monday evening, sleep at Foot's Cray, and try the fly-fishing there.

Will you arrange with Allen, whom we must initiate in the vocation of the Apostles, as he wants nothing else to make him perfect as a primitive Christian and a Philosopher?

I am, my dear Pepys,
Most affectionately yours,
H. Davy.

Hitherto his passion for angling has only been noticed in connection with his conversation and letters; I shall now present to the reader a sketch of the philosopher in his fishing costume. His whole suit consisted of green cloth; the coat having sundry pockets for holding the necessary tackle: his boots were made of caoutchouc, and for the convenience of wading through the water, reached above the knees. His hat, originally intended for a coal-heaver, had been purchased from the manufacturer in its raw state, and dyed green by some pigment of his own composition; it was, moreover, studded with every variety of artificial fly which he could require for his diversion. Thus equipped, he thought, from the colour of his dress, that he was more likely to elude the observation of the fish. He looked not like an inhabitant o' the earth, and yet was on 't;—nor can I find any object in the regions of invention with which I could justly compare him, except perhaps with one of those grotesque personages who, in the Farce of the Critic, attend Father Thames on the stage, as his two banks.

I shall take this opportunity of stating, that his shooting attire was equally whimsical: if, as an angler, he adopted a dress for concealing his person, as a sportsman in woods and plantations, it was his object to devise means for exposing it; for he always entertained a singular dread lest he might be accidentally shot upon these occasions. When upon a visit to Mr. Dillwyn of Swansea, he accompanied his friend on a shooting excursion, in a broad-brimmed hat, the whole of which, with the exception of the brim, was covered with scarlet cloth.

Notwithstanding, however, the refinements which he displayed in his dress, and the scrupulous attention with which he observed all the minute details of the art; if the truth must be told, he was not more successful than his brother anglers; and here again the temperament of Wollaston presented a characteristic contrast to that of Davy: the former evinced the same patience and reserve—the same cautious observation and unwearied vigilance in this pursuit, as so eminently distinguished his chemical labours; the temperament of the latter was far too mercurial; the fish never seized the fly with sufficient avidity to fulfil his expectations, or to support that degree of excitement which was essential to his happiness, and he became either listless or angry, and consequently careless and unsuccessful.—But it is time to resume the thread of our chemical history.

It has been already stated, that Davy had no sooner decomposed the fixed alkalies than he proceeded to effect an analysis of the earths; but his results were indistinct; they could not, like the alkalies, be rendered conductors of electricity by fusion, nor could they be acted upon in solution, in consequence of the strong affinity possessed by their bases for oxygen. The pursuit of the enquiry then demanded more refined and complicated processes, than those which had succeeded with potash and soda.

The only methods which held out any fair prospect of success were those of operating by electricity upon the earths in some of their combinations, or of converting them, at the moment of their decomposition, into metallic alloys, so as to obtain presumptive evidence of their nature and properties. Such, in fact, was the line of enquiry in which Davy was deeply engaged, when he received from Professor Berzelius of Stockholm a letter, announcing the fact that he had, in conjunction with Dr. Pontin, succeeded in decomposing baryta and lime, by negatively electrising mercury in contact with them, and that, by such means, he had actually obtained amalgams of the earths in question.

Our philosopher immediately repeated the experiments, and with perfect success. After which he completed a series of additional experiments, which fully established the nature of these bodies, and the analogies he had anticipated. These results formed the subject of a memoir, which was read before the Royal Society on the 30th of June 1808, and entitled, "Electro-chemical Researches, on the Decomposition of the Earths; with Observations on the Metals obtained from them, and on the Amalgam of Ammonia."

He commences this paper by enumerating the several trials he had made to effect the decomposition of these bodies; such as, First, by electrifying them by iron wires under the surface of naphtha, with a view to form alloys with iron and the metallic bases of the earths. Secondly, by heating potassium in contact with the alkaline earths, in the hope that this body might detach the oxygen from them, in the same manner as charcoal decomposes the common metallic oxides. Thirdly, by submitting various mixtures of the earths and potash to Voltaic action, with the idea that the potash and the earths might be deoxidated at the same time, and entering into combination, form alloys. Fourthly, by mixing together various earths with the oxides of tin, iron, lead, silver, and mercury; a mode of manipulation suggested by the results of his previous experiments on potassium, in which he found that when a mixture of potash and the oxides of mercury, tin, or lead, was electrified in the Voltaic circuit, the decomposition was very rapid, and an amalgam, or an alloy of potassium, was obtained; the attraction between the common metals and the potassium apparently accelerating the separation of the oxygen.

Supposing that a similar kind of action might assist the decomposition of the alkaline earths, he proceeded to institute a series of experiments upon that principle; and the results were more satisfactory than those obtained by the preceding methods of experimenting—a compound was obtained which acted upon water with the evolution of hydrogen, producing a solution of the earth, and leaving free the tin, or lead, with which its base may be supposed to have been alloyed;—but in all such experiments the quantity of the metallic basis produced must have been very minute, and its character very questionable.

In this stage of the enquiry, Davy received the letter from Professor Berzelius of Stockholm, the contents of which he embodied in his memoir, accompanied with such observations as his own information suggested.

" A globule of mercury, electrified by the power of a battery consisting of five hundred pairs of double plates of six inches square, weakly charged, was made to act upon a surface of slightly moistened barytes, fixed upon a plate of platina. The mercury gradually became less fluid, and after a few minutes was found covered with a white film of barytes; and when the amalgam was thrown into water, hydrogen was disengaged, the mercury remained free, and a solution of barytes was formed.

" The result with lime, as these gentlemen had stated, was precisely analogous.

" That the same happy methods must succeed with strontites and magnesia, it was not easy to doubt, and I quickly tried the experiment. From strontites I obtained a very rapid result; but from magnesia, in the first trials, no amalgam could be procured. By continuing the process, however, for a longer time, and keeping the earth continually moist, at last a combination of the bases with mercury was obtained, which slowly produced magnesia, by absorption of oxygen from air, or by the action of water.

" All these amalgams I found might be preserved for a considerable period under naphtha. In a length of time, however, they became covered with a white crust under this fluid. When exposed to air, a very few minutes only were required for the oxygenation of the bases of the earths. In the water the amalgam of barytes was most rapidly decomposed; that of strontites, and that of lime, next in order: but the amalgam from magnesia, as might have been expected from the weak affinity of the earth for water, very slowly changed; when, however, a little sulphuric acid was added to the water, the evolution of hydrogen, and the production and solution of magnesia, were exceedingly rapid, and the mercury soon remained free."

In order, if possible, to procure the amalgams in quantities sufficient for distillation, he combined the methods he had employed in the first instance, with those pursued by Berzelius and Pontin. " A mixture of the earth with red oxide of mercury was placed on a plate of platina, a cavity was made in the upper part of it to receive a globule of mercury, the whole was covered by a film of naphtha, and the plate was made positive, and the mercury negative, by a proper communication with the battery of five hundred."

The amalgams thus procured were afterwards distilled in glass tubes filled with the vapour of naphtha; by which operation the mercury rose pure from the amalgam, and it was very easy to separate a part of it; but the difficulty was to obtain a complete decomposition, for to effect this, a high temperature was required, and at a red heat the bases of the earths instantly acted upon the glass, and became oxidated.

In the best result which Davy obtained in this manner, the barytic basis appeared as a white metal of the colour of silver, fixed at all common temperatures, but fluid at a heat below redness, and volatile at a heat above it. Unlike the alkaline bases, it would seem to be considerably heavier than water.

In extending these experiments to alumine, silex, zircone, &c. after a most elaborate investigation, such results were not obtained as justified the conclusion that they were, like the other earths, metallic oxides; although, as far as they went, they added to the probability of such analogy.

It will be remembered that, after the fixed alkalies had been found to contain oxygen, Davy was very naturally led to enquire whether ammonia might not also contain the same element, or be an oxide with a binary base. In the communication from Professor Berzelius, and Dr. Pontin, already alluded to, a most curious experiment is related on what they consider the deoxidation and amalgamation of the compound basis of ammonia; and which they regard as supporting the idea which Davy had formed of the presence of oxygen* in the volatile alkali. A fact so startling as the production of a metallic body from ammonia, or from its elements, immediately excited in Davy's mind the most ardent desire to pursue the enquiry; and, after repeating the original experiments of the Swedish chemists, with his accustomed sagacity, he modified his methods of manipulation, in order, if possible, to obtain this metallic body in its most simple form; but, although he succeeded in producing the amalgam without voltaic aid, by the intervention of potassium, he could not so distill off the mercury as to leave the basis, or imaginary *ammonium*, free.

The history of these researches into the nature of the ammoniacal element concludes the lecture of which I have endeavoured to give an outline. The subject of the amalgam is still involved in mystery: if we suppose with Davy, that a substance, which forms so perfect an amalgam with mercury, must of necessity be metallic in its own nature, we cannot but conclude either that hydrogen and nitrogen are both metals in the aëriform state, at the usual temperatures of the atmosphere—bodies, for example, of the same character as zinc and quicksilver would be at the heat of ignition—or, that these gases are oxides in their common form, but which become metallized by deoxidation—or, that they are simple bodies, not metallic in their own nature, but capable of composing a metal in their deoxygenated, and an alkali in their oxygenated, state.

Before we venture, however, to entertain any opinions so extravagant in their nature, and so wholly unsupported by analogy, it would be well to enquire how far the change, which ammonia and mercury undergo by Voltaic action, merits the name of amalgamation. Several chemists of the present day are inclined to refer this change of form to a purely mechanical cause, by which the particles of the metal become separated, and converted, as it were, into a kind of *froth* by the operation.†

In the progress of our ascent, it is refreshing to pause occasionally, and to cast a glance at the horizon, which widens at every increase of our elevation. By the decomposition of the alkalies and earths, what an im-

* See page 182.

† While correcting this sheet for the press, I have seen a paper, "On certain phenomena resulting from the action of mercury upon different metals," by Mr. Daniel, in the new Journal of the Royal Institution, which strongly confirms such an opinion.

mense stride has been made in the investigation of nature!—In sciences kindred to chemistry, the knowledge of the composition of these bodies, and the analogies arising from it, have opened new views, and led to the solution of many problems. In Geology, for instance, has it not shown that agents may have operated in the formation of rocks and earths, which had not previously been known to exist? It is evident that the metals of the earths cannot remain at the surface of our globe; but it is probable that they may constitute a part of its interior; and such an assumption would at once offer a plausible theory in explanation of the phenomena of volcanoes, the formation of lavas, and the excitement and effects of subterranean heat, and might even lead to a general theory in Geology.

The reader, for the present, must be satisfied with these cursory hints: I shall hereafter show that our illustrious philosopher followed them up by numerous observations and original experiments in a volcanic country.

I remember with delight the beautiful illustration of his theory, as exhibited in an artificial volcano constructed in the theatre of the Royal Institution.—A mountain had been modelled in clay, and a quantity of the metallic bases introduced into its interior: on water being poured upon it, the metals were soon thrown into violent action—successive explosions followed—red-hot lava was seen flowing down its sides, from a crater in miniature—mimic lightnings played around; and in the instant of dramatic illusion, the tumultuous applause and continued cheering of the audience might almost have been regarded as the shouts of the alarmed fugitives of Herculaneum or Pompeii.

CHAPTER VIII.

Davy's Bakerian Lecture of 1808.—Results obtained from the mutual action of Potassium and Ammonia upon each other.—His belief that he had decomposed Nitrogen.—He discovers Telluretted Hydrogen.—Whether Sulphur, Phosphorus, and Carbon, may not contain Hydrogen.—He decomposes Boracic acid.—Boron.—His fallacies with regard to the composition of Muriatic acid.—A splendid Voltaic Battery is constructed at the Institution by subscription.—Davy ascertains the true nature of the Muriatic and Oxy-muriatic Acids.—Important chemical analogies to which the discovery gave origin.—Euchlorine.—Chlorides.—He delivers Lectures before the Dublin Society.—He receives the Honorary Degree of LL.D. from the Provost and Fellows of Trinity College.—He undertakes to ventilate the House of Lords.—The Regent confers upon him the honour of Knighthood.—He delivers his farewell Lecture.—Engages in a Gunpowder manufactory.—His Marriage.

The third Bakerian lecture, which Davy read before the Royal Society in December 1808, is entitled "An Account of some new analytical Researches on the Nature of certain Bodies, particularly the Alkalies, Phosphorus, Sulphur, Carbonaceous matter, and the Acids hitherto undecompounded; with some general Observations on Chemical Theory."

The object of this lecture was to communicate the results of numerous experiments which had been instituted for the purpose of still farther extending our knowledge of the elements of matter, by the new powers and methods arising from the application of electricity to chemical analysis.

Important as were the facts thus obtained, they disappointed the expectation of those who did not consider, that the more nearly we approach ultimate analysis, the greater must be the difficulties, and the less perfect the results, of our processes. In fact, his former discoveries had spoilt us: their splendour had left our organs of perception incapable of receiving just impressions from any minor lights, and we participated, with exaggerated feelings, in the disappointment which he himself expressed at several of his results. The confidence inspired by his former triumphs may be compared to that which is felt by an army, when commanded by a victorious General,—a conviction that, however difficult may be the enterprise, it must be accomplished by the genius of him who undertakes it. The moment we discovered that Davy was laying siege to one of Nature's strongest holds,—that he was attempting to resolve nitrogen into other elementary forms,—we regarded the deed as already accomplished, and the repulse which followed most unreasonably produced a feeling of dissatisfaction. Upon such occasions, the severity of our disappointment will always be in proportion to the importance of the object we desire to accomplish; and it is impossible not to feel that the discovery of the true nature of nitrogen would lead to new views in chemistry, the extent of which it is not easy even to imagine.

The principal objects of research which this paper embraces are,—the elementary matter of ammonia; the nature of phosphorus, sulphur, charcoal, and the diamond; and the constituents of the boracic, fluoric, and muriatic acids. Enquiries which are continued and extended in two successive papers, viz. in one read before the Society in February 1809, entitled "New Analytical Researches on the Nature of certain Bodies; being an Appendix to his Bakerian Lecture of 1808;" and in his fourth Bakerian Lecture of 1809, "On some new Electro-chemical Researches on various Objects, particularly the Metallic bodies from the Alkalies and Earths; and on some Combinations of Hydrogen."

With regard to these admirable papers,—for such they must undoubtedly be considered,—the biographer must confine his observations to their general character and results. They are far too refined to admit of a brief analysis, and too elaborate to allow a successful abridgement. A just idea of their merit can alone be derived from a direct reference to the Philosophical Transactions.

The enquiry commences with experiments on the results produced by the mutual action of potassium and ammonia on each other. His object was two-fold: to refute the hypothesis which assumed hydrogen as an element of potassium, and to ascertain the nature of the matter existing in the amalgam of ammonia, or the supposed metallic basis of the volatile alkali; a question intimately connected with the whole of the arrangements of chemistry. As to the former point, it is unnecessary to enter into farther discussion; and with regard to the latter, it is quite impossible to convey an adequate idea of the extent of the enquiry: there does not exist in the annals of chemistry a more striking example of experimental skill.

In the course of his experiments on potassium and ammonia, he obtained an olive-coloured body, which he was inclined to regard as a compound of the metallic base of ammonia (*ammonium*) and potassium, and on submitting which to various trials, he uniformly obtained, as the product of its decomposition, a proportion of nitrogen considerably less than that which, upon calculations founded on a rigid analysis of the volatile alkali, ought to have been afforded under such circumstances, while the potassium employed at the same time became oxidated. This result inspired a hope that nitrogen might have been actually decomposed during the process, and that its elements were oxygen and a metallic basis, or oxygen and hydrogen.

That he was sanguine in that hope, appears from the whole tenor of his paper; in further proof of which, I can adduce a letter which he addressed to Mr. Children during the progress of his experiments, in which he says, "I hope on Thursday to shew you nitrogen as a complete wreck, torn to pieces in different ways." His subsequent enquiries, however, although they did not strengthen the suspicion he had formed respecting the decomposition of that body, yet indirectly developed facts of considerable importance; which, with his characteristic quickness of perception, he made subservient to fresh investigation.

His researches into the phenomena exhibited by tellurium, when forming a part of the Voltaic circuit, are highly interesting. It had been stated by Ritter, that, of all the metallic substances he tried for producing potassium by negative electricity, tellurium was the only one by which he could not procure it; and he uses this fact in support of his opinion, that potassium is a *hydruret.* He says, that when a circuit of electricity is completed in water by means of two surfaces of tellurium, oxygen is given off at the positive surface, and instead of hydrogen at the negative surface, a brown powder is formed and separated, which he regards as a *hydruret* of tellurium; and he conceives that the reason why that metal prevents the metallization of potash is, that it has a stronger attraction for hydrogen than that possessed by the alkali.

Davy's attention was naturally arrested by such a statement, and, in pursuing the enquiry, he discovered a series of new facts:—he found that tellurium and hydrogen were capable of combining, and of forming a gas, to which he gave the name of *telluretted hydrogen,*—that, so far from tellurium preventing the decomposition of potash, it formed an alloy with potassium when negatively electrified upon the alkali—and, such was the intense affinity of potassium and tellurium for each other, that the decomposition of potash might be effected by acting on the oxyde of the latter metal and the alkali, at the same time, by heated charcoal.

With respect to the next subject of enquiry in these papers, *viz.* whether sulphur, phosphorus, and carbon, in their ordinary forms, may not contain hydrogen, it would appear that from an experiment performed by Mr. Clayfield, and which Davy witnessed at Bristol in the year 1799, he was very early led to suspect the existence of hydrogen in sulphur; but it was not until 1807, that he entered upon the investigation of the subject. From the general tenor of his experiments he concluded that, in its common state, it may be regarded as a compound of small quantities of oxygen and hydrogen, with a large quantity of a basis which, on account of its strong attractions for other bodies, has not hitherto been obtained in its pure form. The same analogies apply to phosphorus and carbon. His conclusion was mainly derived from the fact, that hydrogen is produced from sulphur and phosphorus in such quantities by Voltaic electricity, that he thinks it cannot well be considered as an accidental ingredient in them; the presence of oxygen, he contends, may be inferred from the circumstance that, when potassium is made to act upon these bodies, the sulphurets and phosphurets so formed evolve by the action of an acid less hydrogen, in the form of compound inflammable gas, than the same quantity of potassium in an uncombined state. The question, however, still remains in considerable doubt; and in his "Elements of Chemical Philosophy," published four years afterwards, he admits that no accurate conclusions have been formed on the subject.

In his second Bakerian lecture of 1807, Davy had given an account of an experiment in which boracic acid appeared to be decomposed by Voltaic electricity, a dark-coloured inflammable substance separating from it on the negative surface. In the memoir now under consideration, he procured the basis by heating together boracic acid and potassium, when he ascertained it to be a peculiar inflammable matter, which, after various experiments upon its nature, he was inclined to regard as metallic; on which account he proposed for it the name of *Boracium.* At about the same period, MM. Gay Lussac and Thenard were engaged in investigating the same subject in France, and they anticipated him in some of the results.

When Davy, by subsequent experiments had ascertained that the base of the boracic acid is more analogous to carbon than to any other substance, he adopted the term *Boron* as less exceptionable than that of *Boracium.*

At this time, he also entered upon the investigation of fluoric acid, the results of which must be reserved for future consideration.

His experiments and reasonings upon muriatic acid, at this period of his career, must be now considered as deriving their greatest degree of interest from their fallacy ; and they deserve an examination in this work, if it be only to estimate the vigour he subsequently displayed in disentangling himself from a web of his own fabrication. The most satisfactory proof of intellectual strength is to be found in the existence of a power which enables the mind to conquer its prejudices and to correct its own errors. How many remarkable instances does the history of science present, in which the philosopher has treated his facts as Procrustes did his victims, in order that they might accord with the measure most convenient for his purpose.

Prejudiced by the general opinion respecting the hitherto undecompounded nature of muriatic acid, Davy had long sought to discover its radical by the agency of Voltaic electricity; but he uniformly found that when its aqueous solution was thus acted upon, the water alone underwent decomposition; while the electrization of the gas afforded no other indication of its nature than the presence of a much greater quantity of water than theory had assigned to it. He proceeded, therefore, to examine the acid by other modes of enquiry: he found, by the action of potassium upon the gas, that a large volume of hydrogen was evolved, which, in conjunction with other experiments, satisfied him that this body, in its common aëriform state, contained at least one-third of its weight of water; and he adopted various expedients with the hopes of obtaining the acid free from it. Without pursuing him through this research, I shall merely state the conclusions at which he arrived, viz. that dry muriatic acid, could it be obtained, would probably be found to possess the strongest and most extensive powers of combination of all known substances belonging to the class of acids; and that its basis, should it ever be separated in a pure form, will be one of the most powerful agents in Chemistry. From the fact of water appearing in a separate state, and oxymuriatic acid being formed whenever a metallic oxide was heated in muriatic acid gas, he was led to consider the muriatic acid as a compound of a certain base, (not hitherto obtained in a separate state,) and not less than one-third part of water—while he regarded oxymuriatic acid as a compound of the same base, (free from water,) with oxygen.

After the numerous experiments in which the original battery of the Institution had been used, so greatly were its metallic plates corroded, that it was found to be no longer serviceable; in consequence of which, as it would appear from a minute, dated July 11, 1808, " Mr. Davy laid before the Managers of the Royal Institution the following paper, viz.

" A new path of discovery having been opened in the agencies of the electrical battery of Volta, which promises to lead to the greatest improvements in Chemistry and Natural Philosophy, and the useful arts connected with them; and since the increase of the size of the apparatus is absolutely necessary for pursuing it to its full extent, it is proposed to raise a fund by subscription, for constructing a powerful battery, worthy of a national establishment, and capable of promoting the great objects of science.

" Already, in other countries, public and ample means have been provided for pursuing these investigations. They have had their origin in this country; and it would be dishonourable to a nation so great, so powerful, and so rich, if, from the want of pecuniary resources, they should be completed abroad.

" An appeal to enlightened individuals on this subject can scarcely be made in vain. It is proposed that the instrument and apparatus be erected in the Laboratory of the Royal Institution, where it shall be employed in the advancement of this new department of science."

The Minute goes on then to state that—

" The above paper having been laid before the Board of Managers, they felt it their indispensable duty instantly to communicate the same to every member of the Royal Institution, lest the slightest delay might furnish an opportunity to other countries for accomplishing this great work, which originated in the brilliant discoveries recently made at the Royal Institution.

" The Managers present agree to subscribe to this undertaking.

" Ordered, that a book be opened at the Steward's office for the purpose of entering the names of all those members who may wish to contribute towards this important National object."

To the great gratification of Davy, and to the honour of the country, the list of subscribers was soon completed, and one of the most magnificent batteries ever constructed was speedily in full operation.

It is thus alluded to in his Elements of Chemical Philosophy:—" The most powerful combination that exists, in which number of alternations is combined with extent of surface, is that constructed by the subscriptions of a few zealous cultivators and patrons of science, in the Laboratory of the Royal Institution. It consists of two hundred instruments connected together in regular order, each composed of ten double plates arranged in cells of porcelain, and containing in each plate thirty-two square inches; so that the whole number of double plates is two thousand, and the whole surface one hundred and twenty-eight thousand square inches."

This battery, when the cells were filled with sixty parts of water mixed with one part of nitric acid, afforded a series of brilliant and impressive effects. When pieces of charcoal, about an inch long, and one-sixth of an inch in diameter, were brought near each other, (within the thirtieth or fortieth parts of an inch,) a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness, and by withdrawing the points from each other a constant discharge took place through the heated air, in a space equal at least to four inches, producing a most brilliant ascending arch of light, broad and conical in form in the middle. When any substance was introduced into this arch, it instantly became ignited; platina melted as readily in it as wax in the flame of a common candle; quartz, the sapphire, magnesia, lime, all entered into fusion; fragments of diamond, and points of charcoal and plumbago rapidly disappeared, and seemed to evaporate in it, even when the connexion was made in a receiver exhausted by the air-pump; but there was no evidence of their having previously undergone fusion.

All the phenomena of chemical decomposition were produced with intense rapidity by this combination. When the points of charcoal were brought near each other in non-conducting fluids, such as oils, ether, and oxymuriatic compounds, brilliant sparks occurred, and elastic matter was rapidly generated.

Among the numerous experiments performed by the aid of this battery, he instituted several, in the hope of decomposing nitrogen; and which are recorded in his Bakerian Lecture of 1809. He ignited potassium, by intense Voltaic electricity, in this gas; and the result was, that hydrogen appeared, and some nitrogen was found deficient. This, on first view, led him to the suspicion that he had attained his object; but, in subsequent experiments, in proportion as the potassium was more free from a coating of potash, which necessarily introduced water, so in proportion was less hydrogen evolved, and less nitrogen found deficient. The general tenor of these enquiries, therefore, did not strengthen the opinion he had formed with respect to the compound nature of nitrogen.

It appears from the following letter, that Davy visited his friend Mr. Andrew Knight at Downton, in September 1809. It is introduced in these memoirs principally for the purpose of showing with what boldness he was accustomed to depart from generally received opinions, and to project new theories for the explanation of the most abstruse subjects.

TO JOHN GEORGE CHILDREN, ESQ.

MY DEAR FRIEND, September 23, 1809.

I AM about to visit Downton, and shall return by the first of October. I have neither seen nor heard from Lord Darnley, and I conjecture he has not yet returned from Scotland.

I wish you great sport in pheasant-shooting, but I trust you have had still nobler game in your Laboratory.

I doubt not you have found before this, as I have done, that the substance we mistook for *sulphuretted* hydrogen is *telluretted* hydrogen, very soluble in water, combinable with alkalies and earths, and a substance affording another proof that hydrogen is an oxide. I have met with another analogous compound, that of *boracium* with hydrogen, which possesses very similar properties.

I find that taking *ammonium* as the basis of hydrogen, according to the ideas which I stated, all the compounds will agree with the suppositions that I mentioned to you, viz. eight cubic inches of hydrogen, two of oxygen, ammonia; four and two, water; four and four, nitrogen; four and six, nitrous oxide; four and eight, nitrous gas; four and ten, nitric acid. Where the multiples are not in geometrical order, the decomposition is most easy, *i. e.* in nitrous oxide and nitric acid; more easy in water than in ammonia; but most difficult in nitrogen, where there is probably the most perfect equilibrium of affinities.

I have kept charcoal white hot by the Voltaic apparatus, in dry oxy-muriatic acid gas for an hour, without effecting its decomposition. This agrees with what I had before observed with a red heat. It is as difficult to decompose as nitrogen, except when all its elements can be made to enter into new combinations.

I find the radiation, *in vacuo*, from ignited platina, is to that in air as three to one:—so much for Leslie's hypothesis.

A little electrical machine acts with a repulsion as two, in a vacuum equal to five inches of mercury; as thirty, in common air; as thirty, in oxygen; as twenty-nine or thirty, in hydrogen; and as forty-five, in carbonic acid. I shewed this experiment, made with every precaution, to Mr. Cavendish, Dr. Herschell, Dr. Wollaston, and Warburton: so much for the theory, that electricity is dependent upon oxidation. I do not think our worthy friend Pepys will resist any longer.

Pray let me know what you have been doing. I hope you will not suffer these beautiful and satisfactory experiments of the capacities of metals to remain still. Write me a letter as egotistical as the one I have given you. You are pledged to do good and noble things, and you must not disappoint the men of science of this country.

With kindest remembrances to your excellent father, and with hopes that we shall soon meet, I am, my dear friend,

Very faithfully and affectionately yours,

H. DAVY.

The genius displayed by Mr. Knight in investigating the phenomena of vegetable nature, and in applying the knowledge thus acquired to objects of practical improvement, excited in Davy, as might have been expected, feelings of the highest admiration; and when, in addition to such claims, he was the acknowledged patron and hospitable friend of the angler, the reader will readily imagine the warmth of feeling with which our philosopher cherished his friendship.

On commencing the present work, I applied to Mr. Knight for any assistance he might be able to afford me, in aid of so arduous a labour; and he very kindly returned an answer, from which I extract the following passage.

" My late lamented friend, Sir Humphry Davy, usually paid me a visit in the autumn, when he chiefly amused himself in angling for grayling, a fish which he appeared to take great pleasure in catching. He seemed to enjoy the repose and comparative solitude of this place, where he met but few persons, except those of my own family, for we usually saw but little company. He always assured me that he passed his visits agreeably, and I had reason to believe he expressed his real feelings.

" In the familiar conversations of these friendly visits, he always appeared to me to be a much more extraordinary being than even his writings, and vast discoveries, would have led me to suppose him; and, in the extent of intellectual powers, I shall ever think that he lived and died without an equal."

The reader has already been made acquainted with those experiments which led Davy to modify the prevailing opinions, with regard to the constitution of the muriatic and oxymuriatic acids; and on the false assumption that oxygen existed in the latter gas, to refer the deposition of water which takes place upon heating a metallic oxide in the former, to the supposition that muriatic acid contains a large proportion of water as essential to its composition. Upon observing, however, that charcoal, if freed from hydrogen and moisture, even when ignited to whiteness in oxymuriatic, or muriatic acid gas, by the Voltaic battery, did not effect the least change in them, he was led to suspect the accuracy of his previous conclusion; and on retracing his steps, and entering upon a new path of enquiry, he ultimately succeeded, after one of the most acute controversies that ever sprang from a chemical question, in recalling philosophers to the original theory of Scheele, by establishing the important truth, that oxymuriatic acid is, in the true logic of chemistry, a simple body, which becomes muriatic acid by its union with hydrogen.

The new views arising out of such a revolution in chemical opinion are certainly not the least important of those to which the discoveries of Davy have given birth. Dr. Johnson has remarked, that " one of the most hazardous attempts of criticism is to choose the best amongst many good." I am much mistaken, however, if the chemists of Europe will not, without hesitation, pronounce that his researches into the nature of oxymuriatic acid, and its relations, with the exception of those by which he established the chemical laws of Voltaic action, are by far the most important of all his labours; not only as evincing the ascendancy of his genius, and the steadiness of his perseverance, but as marking a new and splendid era in chemical science.

It is much more difficult to eradicate an ancient error than to establish a new truth; and on this occasion, he had not only to contend against the pampered errors of a domineering system, but against the equivocal and illusive evidence, or, if I may be allowed the expression, the apparent neutrality of facts by which the truth of his theory was to be judged. In consequence of the constant and often unsuspected interference of water, there is scarcely a result connected with the chemical history of the bodies in dispute, that did not admit of being equally well explained upon the hypothesis that oxymuriatic acid is a compound, as upon that of its being a simple or undecompounded substance. The question could never have been determined but by an investigation of the most refined and subtile nature; so delicately was the evidence balanced, that nothing but the keenest eye, and the steadiest hand, could have determined the side on which the beam preponderated.

The illustrious discoverer of oxymuriatic acid considered that body as muriatic acid freed from hydrogen, or, in the obscure language of the Stahlian school, as muriatic acid deprived of phlogiston, whence he assigned to it the name of *dephlogisticated* muriatic acid. Upon the establishment of the antiphlogistic theory by Lavoisier, it became essential to the generalisation which distinguished it, that a body performing the functions of an acid, and above all, supporting the process of combustion, should be regarded as containing oxygen in its composition; and facts were not wanting to sanction such an inference. The substance could not even be produced from muriatic acid, without the action of some body known to contain oxygen; while the fact of such a body becoming deoxidated by the process, seemed to demonstrate, beyond the possibility of error, that the conversion of the muriatic into the oxymuriatic acid, was nothing more than a simple transference of oxygen from the oxide to the acid; an opinion which was universally adopted, and which for nearly thirty years triumphed without opposition.

The body of evidence by which Davy overthrew this doctrine, and established the undecompounded nature of oxymuriatic acid, is to be found in a succession of papers read before the Royal Society, viz. in that already announced,—in his Bakerian Lecture for 1810,—and in a subsequent memoir read in February 1811.

It will be impossible for me to follow the author through all the intricacies of the enquiry; but I shall seize upon some of its more prominent points, and give a general outline of its bearings.

No sooner had his suspicions been excited with regard to the compound nature of oxymuriatic acid, than it occurred to him that, if oxygen were really present in that body, he might readily obtain it from some of its compounds; that, for instance, its combination with tin would yield an oxide of that metal by ammonia; while those with phosphorus would furnish, on analysis, either the phosphor*ous*, or phosphor*ic* acid. But after experiments, in which the presence of water was most cautiously excluded, the results he had anticipated were not obtained. In the place of an oxide of tin, the product, on the application of heat, volatilized in dense and pungent fumes; and, instead of obtaining an acid of phosphorus, a body possessing new and unexpected properties resulted. Again,—it had been stated, in confirmation of the theory that recognized the presence of oxygen in oxymuriatic acid, that when this latter body and ammonia were made to act upon each other, water was formed; our chemist frequently repeated the experiment, and convinced himself that such was not the fact.

It had been shewn by Mr. Cruickshank, and more recently proved by M. M. Gay Lussac and Thénard, that oxymuriatic acid and hydrogen, when mixed in nearly equal proportions, produce a matter almost entirely condensable by water, which is common muriatic acid; and that water is not deposited in the operation. Davy made many experiments on the subject, and he found, that when these gases were mingled together in equal volumes over water, introduced into an exhausted vessel, and fired by the electric spark, muriatic acid resulted, although, at the same time, there was a certain degree of condensation, and a slight deposition of vapour; but on repeating the experiment in a manner still more refined, and by carefully drying the gases, such condensation became proportionally less.

When, in addition to the above experimental evidence, it is stated that M. M. Gay Lussac and Thénard had proved, by a copious collection of instances, that in the usual cases where oxygen is eliminated from oxymuriatic acid, water is always present, and muriatic acid gas is formed; and as it has been moreover shewn that oxymuriatic is converted into muriatic acid gas by combining with hydrogen, it is scarcely possible to avoid the conclusion, that the oxygen is derived from the decomposition of water, and not from that of the acid.

When mercury is made to act, by means of Voltaic electricity, upon one volume of muriatic acid gas, all the acid disappears, calomel is formed, and half a volume of hydrogen is evolved.

By such experiments and arguments, Davy was led to the conclusion that, as yet, oxymuriatic acid has not been decompounded; that it is a peculiar body, elementary as far as our knowledge extends, and analogous, in its tendency of combination with inflammable matter, to oxygen gas; that, in fact, it may be a *peculiar* acidifying and dissolving principle, forming with different substances compounds analogous to acids containing oxygen, or to oxides, in their properties and powers of combination, but differing from them in being, for the most part, decomposable by water. On this idea, he thinks that muriatic acid may be considered as having hydrogen for its base, and oxymuriatic acid for its acidifying principle. In confirmation of such an opinion, it is also important to remark, that in its electrical relations, oxymuriatic acid maintains its analogy to oxygen.

The vivid combustion of bodies in oxymuriatic acid gas, Davy acknowledges, may, at first view, appear a reason why oxygen should be admitted as one of its elements; but he answers this argument by stating, that heat and light are merely results of the intense agency of combination; and that sulphur and metals, alkaline earths and acids, become alike ignited under such circumstances.

As change of theory with regard to the primitive must necessarily modify all our views with respect to the nature of secondary bodies, so must this new view of oxymuriatic acid affect all our opinions respecting its compounds. Davy accordingly proceeded, in the first place, to investigate the various bodies which had been distinguished by the name of *hyper-oxymuriates, muriates*, &c.

It also became necessary to alter the nomenclature, since to call a body which neither contains oxygen nor muriatic acid, by a term which denotes the presence of both, is contrary to those very principles which first suggested it. Having consulted some of the most eminent philosophers, Davy proposed a name founded upon one of the most obvious and characteristic properties of the oxymuriatic acid, namely, its colour, and called it CHLORINE.

If then oxymuriatic acid, or chlorine, does not contain any oxygen, a question immediately arises as to the true nature of those compounds in which the muriatic acid has been supposed to exist in combination with a much larger proportion of oxygen than in the oxymuriatic acid,—in the state in which it has been named by Mr. Chenevix *hyper-oxygenized* muriatic acid.

In his Bakerian Lecture of 1810, entitled, "On some of the Combinations of Oxymuriatic Gas and Oxygen; and on the Chemical Relations of these Principles," he details a number of experiments for the illustration of this subject, and arrives at the conclusion, that the oxygen in the hyper-oxymuriate of potash is in triple combination with the metal and chlorine. He likewise confirms his views, with regard to the elementary nature of this latter body, by a series of new inquiries; and shews that they are not incompatible with known phenomena: for instance, Scheele explained the bleaching powers of oxymuriatic gas, by supposing that it destroyed colours by combining with *Phlogiston.* Berthollet * considered it as acting by imparting oxygen; Davy now proves that the pure gas is wholly incapable of altering vegetable colours, and that its operation in bleaching entirely depends upon its property of decomposing water, and of thus liberating its oxygen.† The experiment by which he demonstrated this fact is so simple and satisfactory, that I shall here relate it. Having filled a glass globe, containing dry powdered muriate of lime, with oxymuriatic gas, he introduced into another globe, also containing muriate of

* Berthollet first applied oxymuriatic acid for the purpose of bleaching, in France; from whence Mr. Watt introduced it into England.

† Dr. Thomson has more recently explained the operation, by supposing that water is decomposed, and that its hydrogen goes to the chlorine, and its oxygen to the water, forming with the latter a deutoxide of hydrogen, or the oxygenated water of Thénard, which he considers as the true bleaching principle.

lime, some dry paper tinged with litmus, that had been just heated; by which device the intrusion of moisture was effectually prevented. After some time, this latter globe was exhausted, and then connected with that containing the oxymuriatic gas, and by an appropriate set of stop-cocks, the paper was exposed to the action of the gas thus dried; no change of colour in the test paper took place, and after two days, there was scarcely a perceptible alteration; while some similar paper dried and introduced into the gas, that had not been exposed to muriate of lime, was instantly bleached.

As an illustration of the eagerness with which he seized upon facts, in order to apply them to economical purposes, it may be stated that, on reflecting upon the theory of bleaching, and on the changes which its agents undergo, he was led to propose the use of a liquor produced by the condensation of oxymuriatic gas in water, containing magnesia diffused through it, as superior to the oxymuriate of lime commonly employed.*

It has been very truly observed, that all knowledge which is gained tends towards the acquisition of more, just as the iron dug from the mine, facilitates in return the working of the miner. Never was this truth more forcibly illustrated than by the discovery of the nature of chlorine. In the progress of that train of enquiry, which became necessary for the adjustment of our views as they regarded the combinations of that body, Davy discovered a series of new compounds, the history of which he communicated in successive papers to the Royal Society.

In a memoir read in February 1811, entitled, "On a Combination of Oxymuriatic Gas and Oxygen Gas," he announced the existence of a *protoxide* of chlorine, under the name of *Euchlorine;* and in a communication from Rome in the year 1815, he described another compound of chlorine and oxygen, containing a still larger proportion of this latter element, and which has since been made the subject of a series of experiments by Count Stadion of Vienna. As it does not exhibit any acid properties, Dr. Henry proposes to call it a *Peroxide*, in preference to *Deutoxide;* thinking it probable that intermediate compounds, between this and the protoxide already mentioned, may be hereafter discovered.

* Experience has not confirmed the value of this suggestion. Davy imagined that the vegetable fibre was injured by the saline residuum; and having found that muriate of magnesia was less corrosive than muriate of lime, he was led to propose the substitute above stated. The fact, however, is, that the fibre is injured by the chlorine; and as this body has only a slight affinity for magnesia, it too quickly abandons it, and consequently the oxymuriate of lime is still preferred.

His paper on *euchlorine* abounds with interest. He found that by acting on the salts formerly denominated *hyper-oxymuriates*, by muriatic acid, the gas evolved differed very greatly in its properties, with the different modes of preparing it. When much acid was employed with a small quantity of the salt, and the gas was collected over water, it was not found to differ from oxy-muriatic gas; but when, on the other hand, the gas was procured by means of a weak acid, and a considerable excess of the salt, at a low heat, and was collected over mercury, it possessed properties essentially different. Its colour, under such circumstances, was of a dense tint of brilliant yellow-green, whence the name of *euchlorine.** When in a pure form, this gas is so readily decomposed, that it will sometimes explode during the time of its transfer from one vessel to another, producing both heat and light with an expansion of volume,† and it may always be made to explode by a very gentle heat, often even by that of the hand.

The results of its explosion indicate its composition to be one atom of chlorine, and one of oxygen. None of the metals that burn in chlorine act upon this gas at common temperatures; but when the oxygen is separated, they then inflame in the residual chlorine. This fact Davy illustrated by a series of experiments, one of which, from its extreme beauty, I shall here relate. If a glass vessel, containing copper-leaf, be exhausted, and the euchlorine afterwards admitted, no action will take place; but throw in a little nitrous gas, and a rapid decomposition will ensue, and the metal will burn with its accustomed brilliancy.

The discovery of this interesting gas, and that of the facts connected with it, not only confirmed the novel views with regard to the elementary nature of chlorine, but they reconciled the contradictory accounts of different authors respecting the properties of that body.

The weak attraction subsisting between the elements of this compound gas, which by a comparatively low temperature are made repulsive of each other, confirms also the supposition of Davy, that oxygen and chlorine belong to the same class of bodies.

The discovery of the *peroxide of chlorine* was made during an examination of the action of acids on the *hyper-oxymuriates* of Chenevix, undertaken by Davy in consequence of a statement of M. Gay Lussac, that a peculiar acid,

* From ευ and χλωρος.

† The most vivid effects of combustion known are those produced by the *condensation* of oxygen, or chlorine; but in this instance, a violent explosion with heat and light is produced by their separation, and *expansion;* a perfectly novel circumstance in chemical philosophy.

which he called *chloric acid*, might be procured from the *hyper-oxymuriate of baryta* by sulphuric acid. With regard to this acid, which its discoverer considered as composed of one atom of chlorine and five atoms of oxygen, Davy entered into a warm controversy, affirming that the fluid in question owed its acid powers to combined hydrogen; and that it was analogous to the other hyper-oxymuriates, as being triple compounds of inflammable bases with chlorine and oxygen, in which the two former determine the character of the compound: this opinion, however, he afterwards abandoned, and I have reason to believe that he regretted ever having advanced it.

Amidst these new views, it became necessary to alter our opinions with regard to many of those compounds which have been termed *muriates*, but which, it would appear, contain neither muriatic acid nor oxygen, but are, strictly speaking, combinations of metals with chlorine, held in union by a very powerful affinity, since chlorine is capable of expelling the whole of the oxygen from any metallic oxide, and of taking its place; even those metals that are most distinguished by their affinity for oxygen, abandon it whenever their oxides are heated in chlorine, in which case oxygen gas is disengaged.

The same metal is also capable of uniting with different proportions of chlorine, which, so far as has been yet ascertained, are definite, and in no case exceed two proportions to one of metal. Hence it was proposed by Davy, in fixing the nomenclature of these compounds, to designate such as contain the least proportion of chlorine by the termination *ane*, added to the Latin name of the metal, as *cuprane* for that of copper; those containing the larger proportion of chlorine, by the termination *anea*, as *cupranea*. The chemical name of our common culinary salt, in conformity with such a nomenclature, would be *sodane*. This proposition, however, has not been adopted;* the compounds of metals and chlorine are either called *chlorurets*, or what is preferable, from their analogy with the similar compounds of oxygen, *chlorides*, and which are further distinguished, as *protochlorides, deutochlorides*, &c.

In connexion with the history of these chlorides, a question arises of great interest and obscurity, and which has engaged the attention of some of our most distinguished chemists,—whether such a body, when dissolved by water,

* A little reflection will convince us that such a nomenclature could never have been adopted with propriety. It is in direct defiance of the Linnæan precept, that a specific name must not be united to the generic as a termination; besides which, such terms could never have been preserved in translations into other languages.

remains as a chloride; or, by decomposing that fluid, and combining with its elements, is not immediately converted into a muriate? With respect to several of these chlorides, no doubt can be entertained as to the fact of their decomposing water; for instance, the chloride of phosphorus is thus acted upon, the oxygen of the water forms phosphorous acid with the phosphorus, while its hydrogen unites with the chlorine to form muriatic acid; and as those products are such as do not combine with each other, but exist in a state of mixture in the water, each may be recognised by its peculiar properties. In like manner, as Davy has observed, when water is added in certain quantities to Libavius's liquor *(deutochloride of tin)*, a solid crystalline mass is obtained, from which oxide of tin and muriate of ammonia can be obtained by ammonia.

In his Elements of Chemical Philosophy, Davy has been, in many instances, explicit on this point; and his opinions are favourable to the idea that chlorides become muriates by being dissolved in water; thus, he states that the perchloride of iron "acts with violence upon water, and forms a solution of red muriate of iron;" and he observes that the permuriate "forms a solution of green muriate of iron by its action upon water." * With regard, however, to the general principle, that chlorides become muriates by solution, there are difficulties which do not fall within the province of a biographer to discuss. I shall merely observe that such a change is, in many cases, so inconsistent with our preconceived opinions, that very strong evidence is required to reconcile us to its truth. We are undoubtedly prepared to hear that much may happen between the cup and the lip,—but that common salt should be a *chloride of sodium* on our plates, and a *muriate of soda* in our mouths, is certainly a very startling assertion.

The reception which the chloridic theory met with from the chemical world might aptly enough be adduced in illustration of that remark with which I commenced the preceding chapter. At first, its truth was questioned, and no sooner had this been triumphantly established, than an attempt was invidiously made to transfer the glory of the discovery from Davy to the French philosophers. Upon each of these points I shall beg to offer a few observations.

First, with regard to the fact of chlorine being as yet an undecompounded body. The very announcement of a theory so adverse to the universal faith of Europe, was a signal for open hostilities; the observations of Dr. Murray

* For an admirable paper upon this subject by Mr. R. Phillips, in which all the material points of the subject are considered with that acumen which distinguishes its author, see Annals of Philosophy, vol. i. New Series.

may be considered as expressing the sentiments of most of the leading chemists on the first publication of the novel views of Davy. "Opinions," says he, "more unexpected have seldom been announced to chemists, than those lately advanced by Mr. Davy with regard to the constitution of the muriatic and oxymuriatic acids; viz. that the latter is not a compound of muriatic acid and oxygen, but a simple substance, and that the former is a compound of this substance with hydrogen. The more general principle connected with these opinions, that oxymuriatic acid is, like oxygen, an acidifying element, forming with inflammables and metals an extensive series of analogous compounds, leads still more directly to the subversion of the established chemical systems, and to an entire revolution in some of the most important doctrines of the science."

Dr. Murray entered the lists as the avowed partisan of the theory of Berthollet; Dr. Davy, on the other hand, appeared as the champion of his brother's doctrine. A severe contest ensued, and both combatants displayed equal skill and strength. The object of the former was to demonstrate the presence of water, or its elements, as a constituent part of muriatic acid; and he proposed to determine the point by combining the dry gases of muriatic acid and ammonia; for as these bodies did not contain its elements, should water appear, he maintained that it must be considered as pre-existing in the muriatic acid; while, on the contrary, if no water could be procured, it would be unphilosophical to suppose it present, but that muriatic acid gas must, in that case, be considered as a compound of hydrogen and chlorine. In performing this experiment, Dr. Murray did succeed in obtaining a portion of water; but the inference from such a fact was questioned on the other side, upon the assumption of the humidity of the gases. As all parties, however, seemed to agree, that if every source of error could be excluded, the combination of these gases would furnish an *experimentum crucis*, by which the truth or fallacy of either theory might be established, Davy, when at Edinburgh, was desirous of repeating the experiment with Dr. Hope, and it was accordingly made in the College Laboratory. Sir George Mackenzie, Mr. Playfair, and some other gentlemen were present. The results were communicated in Nicholson's Journal by Dr. Davy, and may be briefly stated as follows:—The alkaline and acid gases were pure, and both had been previously dried by exposure for sixteen hours to substances having a strong attraction for water. The apparatus consisted of a plain retort of about the capacity of twenty-six cubic inch measures, with a stop-cock; and of a receiver, with a suitable stop-cock. The latter was filled over mercury with one of the gases, which from the receiver passed into the exhausted retort by means of the stop-cocks; the other gas was introduced the same way into the retort; and thus alternately about ninety cubic inches of each gas were combined. All the salt having then been driven into the bulb of the retort, by the heat of a spirit-lamp, the neck was cooled and kept cold by moistened cloths, whilst the bulb was heated by a coke fire, till the muriate began to sublime, and to make its appearance at the curvature of the vessel when the fire was withdrawn. The result was then examined, while the bottom of the retort was still very hot: a dew, just perceptible, was observed lining the cold neck. The quantity of water was so extremely small, that the globular particles composing this dew could scarcely be perceived by the naked eye; now the quantity of water, according to hypothesis, should equal no less than eight grains. There is no small difference, it must be confessed, between that quantity and a dew barely perceptible, and which may reasonably be referred to a minute quantity of vapour in the gases, or to a little moisture derived from the mercury, a small quantity of which entered the retort with the gases. Dr. Hope wished to ascertain how much water would produce such a dew as was observed. For this purpose he heated in a retort, of a similar size to that used in the experiment, a single drop of water, which it may be said weighs about a grain. The appearance of condensed water, in this instance, in the neck of the retort, was much greater than in the preceding: he considered it as being three or four times as great.

From these results it may be concluded, on Dr. Murray's own ground of reasoning, that water is not a constituent part of muriatic acid gas, and that this substance is a compound merely of chlorine and hydrogen; for it is easy to account for the presence of about one-third of a grain of water from various sources, while it is impossible to account for the absence of eight grains upon any theory except that which supposes the gas to be *anhydrous*.

I shall not pursue the numerous other experiments by which it was attempted to prove the fallacy of Davy's views; they all turn upon the same point, and were refuted by the same vigorous methods of enquiry. The chloridic theory may therefore now be considered as fully established: the philosophers who were for so long a period hostile to its reception, have at length yielded their assent; and Berzelius, in a paper published in the "Annales de Chimie," on the subject of sulpho-cyanic acid, has unconditionally tendered his allegiance; while the subsequent discovery of iodine and bromine has confirmed, by the most beautiful analogies, the views so satisfactorily explained by experiment.

As to the claim of priority which has been urged by several philosophers in favour of the French chemists, Davy, in speaking of Gay Lussac's paper, published in the "Annales de Chimie" for July 1814, observes, that "the historical notes attached to it are of a nature not to be passed over without animadversion. M. Gay Lussac states, that he and M. Thénard were the first to advance the hypothesis that chlorine was a simple body; and he quotes M. Ampere as having entertained that opinion before me. On the subject of the originality of the idea of chlorine being a simple body, I have always vindicated the claims of Scheele; but I must assume for myself the labour of having demonstrated its properties and combinations, and of having explained the chemical phenomena it produces; and I am in possession of a letter from M. Ampere, that shews he has no claims of this kind to make."*

The question of priority appears to me to be readily settled by a reference to printed documents. Davy published his "Elements of Chemical Philosophy," in 1812, containing a systematic account of his new doctrines concerning the combinations of simple bodies. Chlorine is there placed in the same rank with oxygen, and finally removed from the class of acids. In 1813, M. Thénard published the first volume of his "Traité de Chimie Eléméntaire Théorique et Pratique," in which he states the composition of oxymuriatic acid as follows:—"*Composition.* The oxygenated muriatic gas contains the half of its volume of oxygen gas, not including that which we may suppose in muriatic acid." It was not until the year 1816, that, by a note in his fourth volume, he appears to have at all relaxed in his attachment to the old theory of Lavoisier and Berthollet; and it will presently appear, that at the period above mentioned, iodine had been discovered, and its analogies to chlorine fully established by the sagacity of Davy.

Having, as I trust, offered an impartial view of his claims to the establishment of the chloridic theory, I shall resume my narrative of those events which more immediately connect themselves with his personal history at this period.

The great fame of Davy, and the high importance of the discoveries which had bestowed it, became a general theme of admiration throughout the scientific circles of Europe, and induced the members of the Dublin Society to invite him to that city, for the purpose of delivering a course of lectures. From the authentic documents which have been placed in my hands, I am enabled to give a particular account of this transaction.

* Royal Institution Journal, vol. i. p. 283.

As a Meeting of the Dublin Society, held on the 3d of May 1810, the following Resolutions were proposed and unanimously carried, viz.:

1. " That it is the wish of the Society to communicate to the Irish public, in the most extended manner consistent with the other engagements of the Society, the knowledge of a science so intimately connected with the improvement of Agriculture and the Arts, which it is their great object to promote; and that, with this view, it appears to them extremely desirable to obtain the fullest information respecting the recent discoveries made by Mr. Davy, in Electro-chemical science.

2. " Resolved, That application be made to the Royal Society, requesting that they will be pleased to dispense with the engagements of Mr. Davy, so far as to allow the Dublin Society to solicit the favour of his delivering a course of Electro-chemical Lectures in their new Laboratory, as soon as may be convenient after their present course of chemical lectures shall have been completed by their Professor Mr. Higgins.

3. " That the sum of four hundred guineas be appropriated out of the funds of the Society, to be presented to Mr. Davy, as a remuneration for the trouble and expense which they propose he should incur, and as a mark of the importance they attach to the communication which they solicit."

Mr. Leslie Foster having stated to the Dublin Society that the " Farming Society of Ireland" were desirous of availing themselves of this opportunity to apply to Mr. Davy to repeat before them the six lectures on the application of chemistry to agriculture, which he delivered this year (1810) to the Board of Agriculture in England, and that they requested the Dublin Society would accommodate them with the use of their laboratory for that purpose, all the members of the Dublin Society having free admission to such lectures—

The following Resolutions were passed by the Dublin Society:—

" That in the event of Mr. Davy coming over to Ireland, and consenting to deliver the Course referred to, the Farming Society shall be accommodated with the use of the Laboratory, according to their request.

" That it be referred to the Committee of Economy to consider on what terms, and under what regulations, it may be expedient to issue tickets of admission to the Electro-chemical Course, so as to reimburse to the Society the expenses attendant on the arrangement; and that, in order to give the fullest effect to such regulations, the members of the Society renounce any claim to gratuitous admission to this course."

A letter having been addressed to Mr. Davy by the Secretary of the Society, inviting him to Dublin, for the purpose of delivering courses of lectures, in conformity with the foregoing resolutions, the following answer was received from him :—

TO JOHN LESLIE FOSTER, ESQ. M. P. SECRETARY TO THE DUBLIN SOCIETY.

SIR, May 30, 1810.

I HAD the honour of communicating your letter to the President and Council of the Royal Society, who have desired me to express to you, Sir, and through you, to the Dublin Society, the lively interest they feel in the prosperity of that useful public body, and the desire that they have to promote its important object.

On these grounds, they have been pleased to permit me to be absent from the meetings of the Royal Society, during the period that may be necessary for delivering a Course of Lectures at the Laboratory of the Dublin Society, in the month of November next.

Be pleased to express to the Dublin Society my grateful acknowledgments for the honour they have done me in making such a proposition; and assure them that I shall use my best exertions to promote their views for the extension of Chemical Science, and every other species of useful knowledge.

I beg to be permitted to thank you, Sir, for the flattering manner in which you had the goodness to convey to me their proposal.

I am, Sir, with great respect,

Your obliged and obedient servant,

H. DAVY, SEC. R. S.

On the commencement of the Course, on the 8th of November 1810, three hundred and seventy-one admission tickets had been issued; and the Committee of Chemistry having expressed their opinion to the Society, that the lecture-room would not afford accommodation for a greater number of persons, the Assistant Secretary was directed to limit his tickets to that number. On the 15th instant, however, the number was increased to four hundred, without inconvenience.

At the close of the Course, on the 29th of November, the Dublin Society passed the following Resolutions :—

"Resolved, That the thanks of the Society be communicated to Mr. Davy for the excellent Course of Lectures which, at their request, has been delivered by him in their Laboratory; and to assure him that the views which led the Society to seek for these communications, have been answered even beyond their hopes;—that the manner in which he has unfolded his discoveries has not merely imparted new and valuable information, but further appears to have given a direction of the public mind towards Chemical and Philosophical enquiries, which cannot fail in its consequences to produce the improvement of the Sciences, Arts, and Manufactures in Ireland.

"That the thanks of the Society be communicated to the Royal Society for their ready compliance with our request, in dispensing with the engagements of Mr. Davy, during the last six weeks.

"That Mr. Davy be requested to accept the sum of five hundred guineas from the Society."*

The following letter appears, from the date, to have been written about a week before his arrival in Dublin.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, October 12, 1810.

Upon every occasion your recommendation, or opinion, would have great weight with me.

Amongst the candidates for the office of Clerk to the Royal Society, there is one Mr. W——, that I am well acquainted with, and who was formerly attached to the Royal Institution. He appears to me, as well from his scientific character, as from his habits and pursuits, to be admirably fitted for the situation. I advised him nearly two months ago, in consequence of a conversation with Sir Joseph Banks, to offer himself for the situation. I cannot therefore interest myself for any other person who does not possess superior qualifications.

Sir Joseph's maxim, which I hope will be adopted by all the members, is —"let it be given to the most worthy." I have no doubt that Mr. —— would fill the situation with credit, and that he is a very worthy man; but, from all that I can learn, his claims are much inferior to those of W——. We want not merely a civil, gentlemanlike, honest man, but a man a little accustomed to calculation, to astronomical observation, and to experiment.

* There were four hundred tickets issued for the Course, sixty of which were honorary; the produce of the remainder amounted to *672l. 5s. 3d.* Davy received *525l*; and the surplus went to officers and servants, and for the discharge of incidental expenses.

I am in a delightful country here—the Valley of the Tyne—enjoying a few days' leisure after a rather hard chemical campaign, and preparing health and spirits for another in Ireland, where I am going next week.

I hope to be in London by the first week in December. I intend next summer to go into Cornwall—God willing; and I will not go through without seeing you, and telling you that, under all circumstances, I shall always think of you with the warmest esteem, and shall always be

Your sincere friend,

H. Davy.

In the following year, Davy was again solicited by the Dublin Society to deliver lectures in their laboratory; and at a meeting of the members on the 13th of June 1811, a series of resolutions were passed, by which he was empowered to procure copies of many of the geological sketches referred to in a course of lectures he had delivered on geology at the Royal Institution; and also to superintend the construction of a large voltaic battery, for the illustration of the proposed lectures.

In compliance with this request, Davy delivered two distinct Courses; one on the Elements of Chemical Philosophy, the other on Geology, for which he received the unanimous thanks of the Society, and as a more substantial testimony of their gratitude, the sum* of seven hundred and fifty pounds; the receipt of which Davy acknowledged by the following letter.

TO B. MAC CARTHY, ESQ. ASSISTANT SECRETARY TO THE DUBLIN SOCIETY.

SIR, Dublin, December 9, 1811.

I have received your letter, inclosing a draught for seven hundred and fifty pounds Irish.

I am very much gratified by the thanks of the Dublin Society, for the courses of lectures which I had the honour of delivering in their laboratory; and I am proud of their opinion, that they will be useful to the Irish public.

The attention, candour, and indulgence with which they were received by the audience, I shall remember with the warmest feelings of gratitude as long as I live. I have the honour to be, Sir, with much esteem,

Your obliged and obedient servant,

H. Davy.

* These Courses were more numerously attended than those in 1810, there having been issued about five hundred and twenty-five tickets; the proceeds of which were 1101*l.* 2*s.*

Before he quitted Dublin, the Provost and Fellows of Trinity College conferred upon him the honorary degree of LL.D., as an expression of the high admiration which his eminent scientific merits had so universally commanded.

In the month of August, in the same year, his opinion was requested by a committee, as to the best method to be adopted for ventilating the House of Lords; to which circumstance he alludes in the following note to his friend Mr. Pepys.

MY DEAR PEPYS, August 10, 1811.

I FIND that I am engaged on Wednesday, to meet Lord Liverpool, at the House of Lords, to consider a mode of ventilating it.

This business, most unluckily, will prevent my accompanying you; but I shall be glad to go with you on some other day, and to touch up the trout at Cheynies, and afterwards to proceed to Serge Hill.

Very affectionately yours, H. DAVY.

This undertaking, it must be allowed, was on Davy's part a most complete failure: whether he had miscalculated the diameter and number of the apertures necessary for establishing a current, it is difficult to say, but it was obvious that the stream of fresh air thus introduced was by no means adequate to the demand for it.*

The failure, so vexatious to Davy, became to others a fertile source of pleasantry, and numerous epigrams, not exactly of a character to meet the public eye, were very generally circulated, and which, in recording the miscarriage of science, displayed the triumph of wit.

The scientific renown of Davy having attracted the attention of his late Majesty, at that time Prince Regent, he received from his Royal Highness the honour of Knighthood, at a levee held at Carlton House, on Wednesday, the 8th of April 1812; and it may be remarked, that he was the first person on whom that honour had been conferred by the Regent.

On the day following this occurrence, Sir Humphry delivered his farewell lecture before the members of the Royal Institution; for he was on the eve of

* In February 1812, he exhibited a model, in one of his lectures at the Royal Institution, in illustration of his plan; from which it appeared that the air deteriorated by respiration was conducted through three copper pipes, terminating in a single tube, to the roof of the building; and by means of ventilators below there was a constant supply of fresh air, the circulation of which was promoted by a furnace.

assuming a new station in society, which induced him to retire from those public situations which he had long held with so much advantage to the world, and with so much honour to himself. How far such a measure was calculated to increase his happiness I shall not enquire; but I am bound to observe, that it was not connected with any desire to abandon the pursuit of science, nor even to relax in his accustomed exertions to promote its interests. It was evident, however, to his friends, that other views of ambition than those presented by achievements in science, had opened upon his mind; the wealth he was about to command might extend the sphere of his usefulness, and exalt him in the scale of society; his feelings became more aristocratic—he discovered charms in rank which had before escaped him, and he no longer viewed Patrician distinction with philosophic indifference.

On the 11th of April 1812, Sir Humphry married Mrs. Apreece, the widow of Shuckburgh Ashby Apreece, Esq. eldest son of Sir Thomas Apreece: this lady was the daughter and heiress of Charles Kerr, of Kelso, Esq. and possessed a very considerable fortune.

Immediately after the celebration of the marriage, Sir Humphry and his bride proceeded to the hospitable mansion of Sir John Sebright, and afterwards made a tour through Scotland, receiving wherever they went the most flattering marks of attention.

During their excursion, Davy wrote various letters to his scientific friends, several of which I shall introduce; but, in order that those to Mr. Children may be understood, it will be necessary that the reader should be made acquainted with a transaction which occurred in the year 1811.

In consequence of some conversation on gunpowder, during which Davy observed that its composition might be greatly improved by rendering it less *hygrometric*, a proposition was started, that he should join Mr. Children and Mr. Burton in establishing a manufactory for its preparation upon chemical principles. Whether Davy considered himself, in the strict commercial sense, a partner, or merely a chemical adviser, it is perhaps not easy to determine; but it is quite clear that both Mr. Children and Mr. Burton considered him in the former light, although it is an act of justice to those gentlemen to state, that the very moment Davy expressed his disinclination to such an arrangement, they immediately, without the slightest hesitation, released him from all responsibility. This I am enabled to assert, after a most careful investigation of all the correspondence that passed upon the occasion.

TO JOHN GEORGE CHILDREN, ESQ.

MY DEAR FRIEND, Harewood House, July 14, 1812.

I AM very sorry that I missed you the day before I set out on my journey. You will have learnt from your solicitor that I signed the articles. I still think I shall return before any powder will be made, at least, if you do not make it till December, for our present intention is to be in town early in that month.

I sent to you an imperfect copy of my book,* in which there were no engravings, and in which one cancel was not inserted, thinking that you would prefer a copy sent in that way; the cancelled leaf, which you have not, contains a correction for the quantity of nitrous acid gas and water to form the crystalline compound, which is the base of oil of vitriol. Three parts nitrous acid gas condense four parts sulphurous gas.

I have my little apparatus, which will enable me to pursue my experiments on gunpowder. There is one conclusion very obvious resulting from the new facts,—a *perfect* gunpowder ought to contain no more charcoal than is necessary to convert the oxygen of the nitre into carbonic acid. Sulphur forms from nitre just as much elastic fluid as charcoal, *i. e.* if similar quantities of nitre be entirely decomposed, one by charcoal, and one by sulphur, and if the sulphurous gas and the carbonic acid gas be compared, their volumes will be equal. The advantage of forming carbonic acid gas is, that it is more readily disengaged from the alkali. Now it is a question, whether sulphur will decompose *sulphate* of potash,—it will decompose the carbonate; of this we are sure.

There ought then to be just as much sulphur as will form sulphuret of potash with the potash; 191 of nitre, 28·5 of charcoal, and 30 of sulphur, are the true proportions for forming nothing but sulphuret of potash and elastic matter.

Pray send me some cards to circulate; address to me, Post Office, Edinburgh. I hope you got Cavendish's balance.

I have been here for two days; it is a very magnificent place; good fishing for pike, trout, and grayling. Lady D. desires her kind remembrances.

I am, my dear friend, most affectionately yours,

H. DAVY.

* "Elements of Chemical Philosophy," to be presently noticed.

TO THE SAME.

MY DEAR FRIEND, Dunrobin Castle, near Golspie, August 21.

I HOPE you are making progress in our manufactory. I shall expect, on my return, to find your powder the best and strongest, and to make trial of it. I wish I had some of it here, the black-cock and grouse would feel its efficacy. I have been expecting a letter from you every day.

This house is so delightful, the scenery so grand, and the field-sports so perfect, that I think we shall not quit it for a fortnight.

I went to Inverness and fished for salmon. I also went to two or three other places, but not one did I catch till I arrived here. The first day I landed seven noble ones, and played three more in four or five hours. The next day I played eight and landed three, besides white trout in abundance.

I have shot only one day, for a few hours; but we found grouse at every fifty yards, and I shot seven. We are just going to try sea-fishing.

Pray write to me a little news of what is doing for science and the world.

I beg you will remember me most kindly to your father and to Dr. Babington, and Brande, when you see them.

I am, my dear friend,
Most affectionately yours,
H. DAVY.

TO WILLIAM CLAYFIELD, ESQ.

DEAR CLAYFIELD, Dunrobin, near Golspie, August 28, 1812.

I AM much obliged to you for two very kind letters, and for a box containing specimens from St. Vincent.* I beg you will thank the gentleman who was so good as to cause them to be collected for me. The box followed me to Inverness.

The ashes, I think, are likely to fertilize Barbadoes. There is a parallel case of materials having been carried so far in the eruption in Iceland in 1783.

I have been with my wife making a tour through the North since the beginning of July. We have arrived at our extreme point, and shall slowly proceed South in about a fortnight.

* Specimens of substances ejected from the crater in that island, which Mr. Clayfield forwarded to Davy, in consequence of having heard that he had been engaged in examining the sand collected at Barbadoes, and which was a product of the same eruption.

I wish you could be of our party here; we are in a delightful house, that of Lord Stafford, in a country abounding with fish and game. I have caught about thirty salmon since I have been here, and killed grouse, wild ducks, teal, &c. I have not yet shot a stag, but I hope to do so this next week.

I have just published a volume of the Elements of Chemistry, and I hope to publish another in the course of the Spring.

Having given up lecturing, I shall be able to devote my whole time to the pursuit of discovery.

I have not sent you a copy of my book, for I have thought that the best mode of avoiding giving offence to some, was by not making presents at all. Had I not so determined, one of the first copies would have been sent to you, as a mark of the warm esteem and regard of

Your affectionate friend,

H. DAVY.

TO SAMUEL PURKIS, ESQ.

MY DEAR PURKIS, Dunrobin Castle, August 29, 1812.

YOU may probably be surprised to receive a letter from me from this remote corner of the North; but I owe you a letter, and I have a great inclination, wherever I may be, to discharge all debts, and particularly those rendered due by kindness.

Receive my warm acknowledgments for your kind congratulations on my becoming a Benedick. I can now speak from experience, in which you have long participated. I am convinced that the natural state of domestic society is the best fitted for man, whether he be devoted to philosophy, or to active life.

I shall have much pleasure in presenting my wife to you and to Mrs. Purkis, on my return.

We have had a delightful tour through the Highlands. We are at the extreme point of our journey. The pleasures of a refined society—that of Lord and Lady Stafford's family—have induced us to make a long pause here. We think we shall be in London the beginning of December.

I have spent some days such as we passed together in Wales. We have had all the varieties of river, mountain, and wood scenery. The Lakes of Scotland are infinitely finer than those of Wales; but the glens of the Principality may fairly stand in competition with those of the Highlands.

I hope I shall find you and your family in good health, and that you will have spent a very pleasant summer. I am, my dear Purkis,

Very sincerely and affectionately yours,

H. Davy.

TO JOHN GEORGE CHILDREN, ESQ.

MY DEAR FRIEND, Dunkeld, September 27th, 1812.

I have received your two kind letters. I hope your quiet life, and reasonable medical discipline, will entirely restore your health.

We are now on our return, and probably shall arrive in London before the middle of November; our time, however, is uncertain, as the Election may hasten, or keep us back for want of horses.

I can do nothing respecting the licence till my return; I will then see Mr. Wharton, or Mr. Vansittart. I have another subject of conversation in which they are interested, and I can easily introduce that of gunpowder.

I have been tolerably successful as a shot lately. I have not fished. My last adventure was at the Spey, near Gordon Castle, where I killed some noble salmon. At Blair Athol I shot some ptarmigans and a stag. I am now at Dunkeld, which I think the most beautiful habitable spot in the Highlands. The Tay, a noble river, rolls with a majestic stream through lofty woods seated upon cliffs and rounded hills; and in the background are the Mountains of Benyglor and the hills of Killycrankie.

My wife desires her kind remembrances. Pray offer mine to your father and daughter, and believe me to be always

Most affectionately yours,

H. Davy.

TO THE SAME.

MY DEAR FRIEND, Edinburgh, October 14.

We are on our return; I am well, but I am sorry to say that Lady D. is very much indisposed, and anxiety for her hastens my journey to town.

* * * * *

I have received a very interesting letter from Ampere. He says that a combination of chlorine and azote has been discovered at Paris, which is a fluid, and explodes by the heat of the hand; the discovery of which cost an eye and a finger to the author. He gives no details as to the mode of combining them. I have tried in my little apparatus with ammonia cooled very low, and chlorine, but without success.

There is little doing here. * * * * * * dresses and dances—Sir James Hall is writing on a sort of Deluge. Playfair is the true and amiable Philosopher. My brother is making experiments on animal matter.

I hope your gunpowder works are nearly finished. I shall be at the opening ball. As soon as I return I shall give my mind up to this matter. My wife desires her kind remembrances. Mine to your worthy father and Anna.

God bless you, my dear friend, and believe me

Ever affectionately yours,

H. Davy.

On his return to town, after this tour, the following letter was addressed to his friend at Tonbridge:—

MY DEAR CHILDREN, October 24, 1812.

I have just seen Pepys, and rejoice that he gives me so good an account of your health. My wife is much better, except that she has a swollen foot. I have never seen her in such good health and spirits. She is resolved to lead a home life of perfect quiet for six weeks, and I fear you will not be able to tempt her to quit her fire-side, though there is no visit she would make with greater pleasure; but lameness does not suit the country; and for one so enthusiastically fond of nature, it would be vexatious to be in the country, and not to be able to enjoy hills, and meads, and woods.

But I am ready to come to my business whenever you think I can be useful. I shall set to work to make gunpowder with as much ardour as Miles Peter—I hope with similar results.

I shall not be able to endure a very long separation from my wife, but for three or four days I am at your command.

I have been working yesterday and to-day on some new objects; and we are to have a meeting on Wednesday, at one o'clock, at the Institution, to try to make this compound of azote and chlorine, and to try some other experiments. Afterwards we (Angling Chemists) propose a dinner at Brunet's. If you can come to town on that day, I will promise to return with you.

God bless you, my dear Children, and believe me to be

Most affectionately yours,

H. Davy.

CHAPTER IX.

Davy's "Elements of Chemical Philosophy" examined.—His Memoir on some combinations of Phosphorus and Sulphur, &c.—He discovers Hydro-phosphoric gas.—Important Illustrations of the Theory of Definite Proportionals.—Bodies precipitated from water are Hydrats.—His letter to Sir Joseph Banks on a new detonating compound.—He is injured in the eye by its explosion.—His second letter on the subject.—His Paper on the Substances produced in different chemical processes on Fluor Spar.—His work on Agricultural Chemistry.

The "Elements of Chemical Philosophy," a work to which he has alluded in several of the preceding letters, was published in June 1812. It is dedicated to Lady Davy, to whom he offers it "as a pledge that he shall continue to pursue Science with unabated ardour."

This work, although only a small part of the great labour he proposed to accomplish, must be considered as one of high importance to the cause of science. It has not perhaps announced any discoveries which had not been previously communicated to the Royal Society, but it has brought together his original results, and arranged them in one simple and digested plan—it has given coherence to disjointed facts, and has exhibited their mutual bearings upon each other, and their general relations to previously established truths.

Very shortly after the publication of this first part, it was asserted by a scientific critic that the work could never be completed upon the plan on which it had commenced, which was little less than a system of chemistry, in which all the facts were to be verified by the author; an undertaking far too gigantic for the most intrepid and laborious experimentalist to accomplish. There was too much truth in the remark—the life of the Author has closed—the work remains unfinished.

Although it bears the title of "Elements," its plan and execution are rather adapted for the adept than the Tyro in science; it has, however, enabled the discoverer to expand several of his opinions with a freedom which is not consistent with the studied compression and elaborate brevity that necessarily characterise the style of a Philosophical Memoir,—and thus far it may have served the more humble labourer.

The first impression which this volume must produce, is that of admiration at the rapid and triumphant progress of Chemistry, during the period of a very few years; while a comparison of this work with others, even of very recent date, will show how much we are indebted for this progress to the unrivalled labours of Davy.

The first part of his projected system, which constitutes the volume under review, extends only to the general laws of chemical changes, and to the primary combinations of undecompounded bodies. It is resolved into seven divisions, upon each of which I propose to offer some remarks.

The First Division embraces the consideration of the three different forms of matter, viz: Solidity, Liquidity, and elastic Fluidity; and that of the active powers on which they depend, and by which they are changed, such as Gravitation, Cohesion, Calorific repulsion, or Heat, and Attractions chemical and electrical. The laws of which he has expounded in a lucid and masterly manner; although it will be only necessary to quote the following passage, to show that the greatest philosopher may occasionally slide into error. "In solids, the attractive force predominates over the repulsive; in fluids, and in elastic fluids, they may be regarded as in different states of equilibrium; and in ethereal substances, the repulsive must be considered as predominating over and destroying the attractive force." A reviewer has very justly observed, that it is difficult to conceive how so much error and confusion could have been collected, by such an author, into so short a sentence. It is a solecism to say that two forces may exist in different states of equilibrium; besides, it is generally admitted that the repulsive force alone exists in elastic fluids, and that it is only compensated by external pressure, or gravitation.

In treating the subject of Heat, he maintains the same opinion, though in a manner somewhat more subdued, as that which he had formed at the very commencement of his scientific career,* that it is nothing else than motion, and that the laws of Heat are the same as the laws of Motion.

In taking a general view of the subject of Chemical Attraction, there is a remarkable clearness in his enunciation of its several propositions, and a great felicity in the selection of its illustrations. He combats the theory of Berthollet, respecting the influence of mass, with singular success, and confirms the

* See Page 32 of these Memoirs.

general law, that all bodies combine chemically, in certain definite proportions to be expressed by numbers; so that, if one number be employed to denote the smallest quantity in which a body combines, all other quantities of the same body will be as multiples of this number; and the smallest proportions in which the undecompounded substances enter into union being known, the constitution of the compound they form may be learnt; and the element which unites chemically in the smallest quantity being expressed by unity, all the other elements may be represented by the relations of their quantities to unity. Unfortunately, however, there has existed amongst philosophers a want of agreement as to the *unit* to which the relative values of the other numbers shall be referred. Mr. Dalton selected Hydrogen as the unit; Davy followed his example, but doubled the weight of oxygen; while Wollaston, Thompson, and Berzelius, have proposed oxygen as the most convenient unit, since that element enters into the greatest number of combinations.

To Dalton is now universally conceded the glory of having established the laws of definite proportions; but in unfolding them, he has employed expressions which involve speculations as to their physical cause, and has thus given to that, which is nothing more than a copious collection of facts, the appearance of a refined theory. It may be perfectly true, as Mr. Dalton supposes, that all bodies are composed of ultimate atoms, but in the present state of our knowledge, we can neither form any idea of the nature of such atoms, nor of the manner in which they may be grouped together. We are, therefore, indebted to Davy for having, by his early and powerful example, taught the chemist how to disentangle fact from hypothesis, and to investigate the doctrine of proportionals, without any reference to the atomic theory which has been proposed for its explanation.

The Second Division treats of Radiant or Ethereal Matter, and of its effects in producing vision, heat, and chemical changes. It contains some refined speculations respecting the possible conversion of terrestrial bodies into light and heat, and *vice versâ.*

The Third Division presents us with an account of "Empyreal undecompounded Substances," or those which support combustion; together with that of the compounds which they form with each other. Upon this occasion, Davy has completely rescued us from the trammels of the Anti-phlogistic theory, and has shown that, so far from the process of combustion depending upon the position or transfer of oxygen, it is a *general* result of the actions of *any* substances possessed of strong chemical attractions, or different electrical relations, and that it takes place in all cases in which an intense and violent motion can be conceived to be communicated to the corpuscules of bodies, without any regard to the peculiar nature of the substances engaged.* The announcement of the general law is followed by a history of the only two undecompounded bodies included under this arrangement, viz. *Oxygen*, and *Chlorine.* In naming a class of bodies by their relations to combustion, he distinctly states that he merely intends to signify that the production of heat and light is more characteristic of their actions, than of those of any other substances; and that they are, at the same time, opposed to all other undecompounded substances by their electrical relations, being always in voltaic combinations attracted to, or elicited from the positive surface; whereas all other known undecompounded substances are separated at the negative surface.

The Fourth Division comprises the history of Undecompounded Inflammables, or Acidiferous Substances, not Metallic, and that of their binary combinations with oxygen and chlorine, or with each other.

The bodies considered under this division, are six, viz. Hydrogen, Azote, Sulphur, Phosphorus, and Boracium, or Boron. Under the history of Sulphur, he gives us the true theory of the process by which sulphuric acid is produced by the combustion of that body in mixture with nitre, and which had never before been explained in any chemical work.

The Fifth Division contains the Metals; their primary combinations with other undecompounded bodies, and with each other.

In the order of classification adopted on this occasion, the newly discovered inflammable metals, producing by combustion alkalies, alkaline earths, and earths, commence the series; next come those which produce oxides; and lastly, those which produce acids. Thus are we presented with a chain of gradations of resemblance which may be traced throughout the whole series of metallic bodies.

The Sixth Division comprehends certain bodies (the *Fluoric Principle*, and the *Ammoniacal Amalgam*) which present some extraordinary and anomalous results. It is worthy of remark, that, at the period at which this work was written, Davy considered the peculiar acid developed from fluor spar, by the action of sulphuric acid, as a compound of an acid unknown in a separate state, and water; whence he proposed to call it *Hydro-fluoric* acid, a term extremely objectionable from its ambiguity, since it would indicate either hydrogen or water as one of its constituents. At the conclusion, however, of

* *Iodine*, *Fluorine*, &c. had not been discovered at this period.

this chapter, in consequence of having observed certain phenomena displayed by this gas, when in combination with silica and boracic acid, he for a moment seems to have caught the truth, but it as quickly eluded his grasp, and he dismisses the conjecture which it was his good fortune some years afterwards to verify, viz. that the fluoric acid is a compound of an unknown principle, analogous to chlorine, with hydrogen and water, and that *fluor spar* is a compound of the same principle with calcium, or the base of lime.

The Seventh Division offers to the chemical enquirer various speculations, as to the probable nature of certain bodies hitherto undecompounded. He observes, that " we know nothing of the true elements belonging to nature; but as far as we can reason from the relations of the properties of matter, that hydrogen is the substance which approaches nearest to what the elements may be supposed to be. It has energetic powers of combination, its parts are highly repulsive of each other, and attractive of the particles of other matter; it enters into combination in a quantity very much smaller than any other substance, and in this respect it is approached by no known body. After hydrogen, oxygen perhaps partakes most of the elementary character; it has a greater energy of attraction, and, with the exception just stated, enters into combination in the smallest proportion."

In conclusion, he hints at the possibility of the same ponderable matter in different electrical states, or in different arrangements, constituting substances chemically different, and he thinks that there are parallel cases in the different states in which bodies are found connected with their different relations to temperature; thus, steam, ice, and water, are the same ponderable matter; and certain quantities of steam and ice mixed together produce ice-cold water.

" That the forms of natural bodies may depend upon different arrangements of the same particles of matter has been a favourite hypothesis, advanced in the earliest era of physical research, and often supported by the reasonings of the ablest philosophers. This sublime chemical speculation, sanctioned by the authority of Hooke, Newton, and Boscovich, must not be confounded with the ideas advanced by the alchemists, concerning the convertibility of the elements into each other. The possible transmutation of metals has generally been reasoned upon, not as a philosophical research, but as an empirical process. Those who have asserted the actual production of the precious metals, or their decomposition, or who have defended the chimera of the philosopher's stone, have been either impostors, or men deluded by impostors. In this age of rational enquiry, it will be useless to decry the practices of the adepts, or to caution the public against confounding the hypothetical views respecting the elements founded upon distinct analogies, with the dreams of alchemical visionaries, most of whom, as an author of the last century justly observed, professed an art without principles, the beginning of which was deceit, and the end poverty."

On the 18th of June 1812, Davy presented to the Royal Society a paper entitled, " On some Combinations of Phosphorus and Sulphur; and on some other subjects of Chemical Inquiry."

By the researches detailed in this Memoir, he accomplished three important objects: he established the existence of some new compounds — furnished additional evidence in support of the doctrine of definite proportions—and ascertained that most of the substances obtained from aqueous solutions by precipitation, are compounds of water, or *Hydrats*. In the first place, he recognised the formation of two distinct compounds of phosphorus and chlorine, one solid, white, and crystalline in its appearance; the other fluid, limpid as water, and volatile. The latter body he found to contain just double as much chlorine as the former.

On experimenting upon this latter body with water, he obtained a crystallized substance which he proposed to call *Hydro-phosphorous acid*, since it consists of pure phosphorous acid and water. By decomposition in close vessels it is resolved into phosphoric acid, and a peculiar gas, consisting of one proportional of phosphorus and four of hydrogen, and for which he proposed the term *Hydro-phosphorous* gas. The reader, no doubt, will be immediately struck with the impropriety of a nomenclature in which the prefix *Hydro* is made to express water in the former, and hydrogen in the latter instance.

In examining the results of the mutual decomposition of water and the phosphoric compounds of chlorine, Davy remarks, that it is scarcely possible to imagine more perfect demonstrations of the laws of definite combination; no products are formed except the new combinations, (phosphor*ic* acid from the solid, phosphor*ous* acid, from the liquid compound, and in both muriatic acid,) neither oxygen, hydrogen, chlorine, nor phosphorus, is disengaged, and therefore the ratio in which any two of them combine being known, the ratio in which the rest combine, in these cases, may be determined by calculation.

Lastly, he ascertained that most of the substances obtained by precipitation from aqueous solutions are compounds of water; thus zircona, magnesia, and silica, when precipitated and dried at 212°, still contain definite proportions of water; and many of the substances which had been considered as metallic oxides, he found, when obtained from solutions, to agree in this respect; and that their colours and other properties are materially influenced by this combined water.

On the 5th of November 1812, was read before the Royal Society a letter addressed by Davy to Sir Joseph Banks, on the subject of the detonating compound already alluded to in his communications to Mr. Children. He expresses his anxiety to have the circumstances made public as speedily as possible, since experiments upon the substance may be connected with very dangerous results.

He had some time before received information from Paris of a combination having been effected between chlorine and azote, and that it was distinguished by detonating properties; but he was wholly ignorant of the mode by which it had been prepared, and he could not obtain any information upon this point from any of the French journals.

So curious and important a result could not fail to interest him, as he had himself been long engaged in experiments on the action of azote and chlorine, without gaining any decided proofs of their power of combining with each other. It was evident from the notice, that this new body could not be formed in any operations in which heat is concerned; he therefore attempted to combine the elements by presenting them to each other artificially cooled, the azote being in a nascent state. For this purpose he introduced chlorine into a solution of ammonia; a violent action ensued, and minute films of a yellow colour were observed on the surface of the liquor, but they immediately resolved themselves into gas. As he was about to repeat the experiment with some other ammoniacal compounds, Mr. Children reminded him of the circumstance which he had previously communicated to him in a letter, that Mr. James Burton, jun^r^, on exposing chlorine to a solution of nitrate of ammonia, had observed the formation of a yellow oil, but which he had not been able to collect. Davy availed himself of the hint, and obtained the substance in question; on examining its properties by the application of heat, the tube in which it was contained was shivered to atoms by its explosion, and he received a severe wound in the transparent cornea, which was followed by inflammation, and disabled him from pursuing his enquiry.

In the following July, however, he communicated in a second letter to Sir Joseph Banks, the continuation of this enquiry, and furnished a full and satisfactory history of the body in question. Having procured it in sufficient quantity, he attempted to effect its analysis by the action of mercury, but a violent detonation occurred, and he was again wounded in the head and hands; fortunately, however, the injury was slight, in consequence of his having taken the precaution to defend his face by a plate of glass attached to a proper cap.

In a subsequent experiment, by using smaller quantities, and recently distilled mercury, he succeeded in obtaining results without any violence of action; the mercury united with the chlorine, and the azote was disengaged; from which he was enabled to conclude that it was composed of four volumes of chlorine and one volume of azote. For this new body Davy suggested the name of *Azotane*, but I have already observed, that his nomenclature of the compounds of chlorine has never been adopted; the detonating substance is now very properly denominated *Chloride of Nitrogen*.

Shortly after the publication of this paper, M. Berzelius, in a letter to Professor Gilbert, asserted that "*Azotane*" is nothing more than *dry* nitro-muriatic acid, since it dissolves slowly in water, and forms a weak *aqua regia*. "These few observations," says he, "show clearly that Davy's analysis of this substance is inaccurate, and that he corrected his results in consequence of theoretical views."

This was an imputation upon the philosophical character of Davy, which excited in him no small degree of indignation. In reply, he says, "It is difficult to discover what meaning M. Berzelius attaches to the term *dry* nitro-muriatic acid; and it is wholly unnecessary to refute so unfounded and vague an assertion."

On July 8, 1813, a paper was read by Davy before the Royal Society, entitled "Some Experiments on Observations on the Substances produced in different chemical processes on Fluor Spar."

The views which he formerly entertained with respect to the fluoric acid have been already noticed;* in the present paper he renounces his previous opinions, and establishes, by experiments of the most satisfactory character, that the base of fluoric acid is a highly energetic body not hitherto obtained in an insulated form, and the properties peculiar to which are as yet unknown. It appears, however, to belong to the class of negative electrics, and, like oxygen and chlorine, to have a powerful affinity for hydrogen and metallic substances. With hydrogen it constitutes the peculiar and very powerful acid long known by the name of *fluoric acid*,—with boron, the *fluoboric*, and with silicium, the *silicated-fluoric*, acids. Although this theory had

* See page 229.

originally suggested itself to the mind of Davy, yet the chemical world is unquestionably indebted to M. Ampere for establishing it; and the English chemist has very justly acknowledged the obligation. "During the period that I was engaged in these investigations," says he, "I received two letters from M. Ampere, of Paris, containing many ingenious and original arguments in favour of the analogy between the muriatic and fluoric compounds. M. Ampere communicated his views to me in the most liberal manner; they were formed in consequence of my ideas on chlorine, and supported by reasonings drawn from the experiments of M. Gay Lussac and Thénard."

It has been stated that Davy gave his last public lecture on the 9th of April 1812; he however afterwards delivered an occasional lecture to the managers, on his own discoveries, and did not formally resign his professorship until the next year.

The following record has been extracted from the Journal of the Institution.

"Minutes of the Proceedings of a general Monthly Meeting of the Members of the Royal Institution, held on Monday, April 5, 1813.

"Earl of Winchelsea, President, in the Chair.

"This being the meeting appointed by Article 2. chap. xix. of the byelaws, for putting in nomination from the chair the professors for the year ensuing, Sir Humphry Davy rose, and begged leave to resign his situation of Professor of Chemistry; but he by no means wished to give up his connection with the Royal Institution, as he should ever be happy to communicate his researches, in the first instance, to the Institution, in the manner he did in the presence of the members last Wednesday, and to do all in his power to promote the interest and success of this Institution.

"Sir H. Davy having retired, Earl Spencer moved, That the thanks of this Meeting be returned to Sir H. Davy for the inestimable services rendered by him to the Royal Institution. This motion was seconded by the Earl of Darnley, and on being put, was carried unanimously.

"Earl Spencer further moved, That in order more strongly to mark the high sense entertained by this Meeting of the merits of Sir H. Davy, he be elected Honorary Professor of Chemistry; which, on being seconded by the Earl of Darnley, met with unanimous approbation.

"The Chairman having declared the Professorship of Chemistry vacant, put in nomination William Thomas Brande, Esq. F. R. S. as a candidate for that office, with a salary of 200*l.* per annum.

"On Monday, June 7, 1813, William Thomas Brande, Esq. was unanimously elected."

In March 1813, Davy published his "Elements of Agricultural Chemistry," being the substance of a course of lectures which he had, for ten successive seasons, delivered before the members of the Board of Agriculture, to whom the work is inscribed, as a mark of the author's respect.

This work, which may be considered as the only system of philosophical agriculture ever published in this country, has not only contributed to the advancement of science, but to that for which he has an equal claim upon our gratitude,—the diffusion of a taste amongst the higher classes for its cultivation; for it has been wisely remarked, that not he alone is to be esteemed a benefactor to mankind who makes an useful discovery, but he, also, who can point out an innocent pleasure.

It has been already stated, that Davy became early impressed with the importance of the subject:—that in future life its investigation should have been to him so fertile a source of pleasure may be readily imagined, when it is remembered with what passionate delight he contemplated the ever varying forms of creation. "I am," said he, "a lover of nature, with an ungratified imagination, and I shall continue to search for untasted charms—for hidden beauties." In unfolding, then, the secrets of vegetable life, he did but remove the veil from his mistress. From the same poetical feeling sprang his love of angling; it was a pursuit which carried him into the wild and beautiful scenery of Nature, amongst the mountain lakes, and the clear and lovely streams that gush from elevated hills, or make their way through the cavities of calcareous strata.* In the early spring it led him forth upon the fresh turf in the vernal sunshine, to scent the odour of the bank perfumed by the violet, and enamelled with the primrose, while his heart participated in the renovated gladness of Nature.

I had hoped that, amidst the voluminous correspondence of my late friend Mr. Arthur Young, some important letters might have been found from Davy on agricultural subjects: but the communications which took place between them were generally in conversation, and I have therefore only been able to procure two letters, which I shall here insert: the first will shew that, during his tours, his attention was alive to the practices of husbandry; and the second will prove that he had once seriously contemplated the labour of writing the agricultural history of his native county.

* See his Salmonia, Edit. 2. p. 9.

TO ARTHUR YOUNG, ESQ.

DEAR SIR, Killarney, June 1806.

You have been of great and durable service to Ireland. I have met with a number of persons who have been enlightened by your labours, and who now follow an enlightened system of Agriculture; one very intelligent gentleman you will recollect,—Mr. Bolton of Waterford: he is zealously pursuing improvements, and is instructing his neighbours by precept and example.

I am, &c.

H. Davy.

The above letter contains also some observations on a chemical mixture, but which is unintelligible from our being ignorant of the conversation to which it refers.

TO THE SAME.

DEAR SIR, April, 1807.

I called this morning with the hope of seeing you, and of gaining some explanation on the subject of your note. I shall not be able to leave London until the middle of July, and I must return early in October.

I do not think there would be sufficient time between these periods for accomplishing the objects you mention; nor do I think myself qualified to write upon the agriculture of a county. I wished likewise to devote the leisure of this summer to the preparation of my lectures on the chemistry of agriculture for publication. I have a great deal of information concerning the mineralogy and geology of Cornwall, but none concerning the farming.

If the business admits of being postponed, I might perhaps be able to accomplish it next summer; that is, by devoting a part of this summer, and the whole of my next; but I would rather confine myself to my own province, the mineralogy and geology of the county, and leave the agriculture to abler hands.

Be pleased to receive my thanks, and to communicate them to the President for the honour of the proposal. I remain, &c.

H. Davy.

The majority of my readers will probably concur in the wisdom of this decision; they will consider that to have doomed Davy to a drudgery of this nature, would have been wasting talents upon an object which might be accomplished by smaller means: from my acquaintance, however, with Cornwall, I am induced to form a different opinion. Davy never approached even those subjects which had already received from others the most thorough investigation, without extracting from them new and important truths; what, then, might not have been expected from his genius, when applied to a department upon which the light of science had scarcely dawned?

It is only in a primitive country like Cornwall, that the natural relations between the varieties of soil and the subjacent rocks can be studied with success; as we advance to alluvial districts, such relations become gradually less distinct and apparent, and are ultimately lost in the confused complication of the soil itself, and in that general obscurity which envelopes every object in the ulterior stages of decomposition. We can, therefore, only hope to succeed in such an investigation by a patient and laborious examination of a primitive country, after which we may be enabled to extend our enquiries with greater advantage through those regions which are more completely covered with soil, and obscured by luxuriant vegetation; as the eye, acquainted with the human figure, on gazing upon a beautiful statue, traces the outline of the limbs, and the swelling contour of its form, through the flowing draperies which invest it. The importance of the subject, as well as the general interest it has excited, induce me to offer an analysis of his "Elements of Agricultural Chemistry."

The work is divided into eight lectures; and in his introductory chapter, after adverting to the difficulties which the enquiry presents to the lecturer, he offers a general view of the objects of the course, and of the order in which he proposes to discuss them.

"Agricultural Chemistry has not yet received a regular and systematic form. It has been pursued by competent experimenters for a short time only; the doctrines have not as yet been collected into an elementary treatise; and on an occasion when I am obliged to trust so much to my own arrangements, and to my own limited information, I cannot but feel diffident as to the interest that may be excited, and doubtful of the success of the undertaking. I know, however, that your candour will induce you not to expect any thing like a finished work upon a science as yet in its infancy; and I am sure you will receive with indulgence the first attempt made to illustrate it, in a distinct course of lectures.

"Agricultural Chemistry has for its objects all those changes in the arrangements of matter connected with the growth and nourishment of plants;

the comparative values of their produce as food; the constitution of soils; and the manner in which lands are enriched by manure, or rendered fertile by the different processes of cultivation." That such objects are intimately connected with the doctrines of chemistry, he proceeds to shew by several appropriate and striking illustrations.

" If land be unproductive, and a system of ameliorating it is to be attempted, the sure method of obtaining the object is, by determining the cause of its sterility, which must necessarily depend upon some defect in the constitution of the soil. which may be easily discovered by chemical analysis. Are any of the salts of iron present? they may be decomposed by lime. Is there an excess of siliceous sand? the system of improvement must depend on the application of clay and calcareous matter. Is there a defect of calcareous matter? the remedy is obvious. Is an excess of vegetable matter indicated? it may be removed by liming, paring, and burning. Is there a deficiency of vegetable matter? it is to be supplied by manure."

In the selection also of the remedy, after the discovery of the evil, chemical knowledge is of the highest importance. Limestone varies in its composition, and by its indiscriminate application we may aggravate the sterility we seek to obviate. Peat earth is an excellent manure, but it may contain such an excess of iron as to be absolutely poisonous to plants. How are such difficulties to be met, but by the resources of chemistry? It is also evident that the scientific agriculturist should possess a general knowledge of the nature and composition of material bodies, and the laws of their changes; for the surface of the earth, the atmosphere, and the water deposited from it, must, either together or separately, afford all the principles concerned in vegetation; and it is only by examining the chemical nature of these principles, that we are capable of discovering what is the food of plants, and the manner in which this food is supplied and prepared for their nourishment.

Davy likewise advocates the necessity of studying " the phenomena of vegetation, as an important branch of the science of organized nature; for although exalted above inorganic matter, vegetables are yet in a great measure dependent for their existence upon its laws. They receive their nourishment from the external elements; they assimilate it by means of peculiar organs; and it is by examining their physical and chemical constitution, and the substances and powers which act upon them, and the modifications which they undergo, that the scientific principles of Agricultural Chemistry are obtained."

With respect, however, to the practical utility of this latter branch, different opinions have been entertained. I confess I am inclined to agree with an able reviewer,* when he says, " It is the proper business of the chemist to examine and ascertain the nature and properties of dead and inorganized matter, and the various combinations which, according to chemical laws, it is capable of forming. The chemical composition of organized bodies, and of the products which they form, fall likewise under his cognizance; but when he proceeds to consider the physical constitution of these bodies, and the manner in which they act in forming their products, he no longer works with the instruments of the laboratory, or conducts processes which can be properly imitated there."

In concluding his introductory observations, he remarks upon the prejudice which persons, who argue in favour of practice and experience, very commonly entertain against all attempts to improve agriculture by philosophical enquiries and chemical methods. " That much vague speculation may be found in the works of those who have lightly taken up agricultural chemistry, it is impossible to deny. It is not uncommon to find a number of changes rung upon a string of technical terms, such as oxygen, hydrogen, carbon, and azote, as if the science depended upon words, rather than upon things. But this is, in fact, an argument for the necessity of the establishment of just principles of chemistry on the subject." " If a person journeying in the night wishes to avoid being led astray by the ignis fatuus, the most secure method is to carry a lamp in his own hand."

" There is no idea more unfounded than that a great devotion of time, and a minute knowledge of general chemistry is necessary for pursuing experiments on the nature of soils, or the properties of manures. The expense connected with chemical enquiries is extremely trifling; a small closet is sufficient for containing all the materials required."

In the Second Lecture, he enters upon the consideration of the general powers of matter, such as gravitation, cohesion, chemical attraction, heat, light, and electricity; and then proceeds to examine the elements of matter, and the laws of their combinations and arrangements.

To an audience constituted of persons who were not familiar with the elementary principles of the science, it might have been very necessary for the lecturer to enter upon such preliminary details; but there cannot be any good reason for his having published them in his system. As they are

* Edinburgh Review, vol. 22. page 253.

to be found in every work on chemistry, it will not be necessary to bestow upon them any further notice.

In the Third Lecture, he enters into a description of the organization and living system of plants; in which he connects together into a general view, the observations of the most enlightened philosophers who have studied the physiology of vegetation—those of Grew, Malpighi, Sennebier, Hales, Decandolle, Saussure, Bonnet, Darwin, Smith, and, above all, of Mr. Knight, whose enquiries upon these subjects are not only the latest, but by far the most satisfactory and conclusive.

As there is little in these descriptions that may not be found in the original authors, I shall not unnecessarily trespass upon the time of the reader by relating them. In the latter part of this lecture, he describes the properties and ultimate composition of the proximate principles of which vegetable matter consists, and into which it may be resolved by different processes of art; such are gum, starch, sugar, albumen, gluten, extract, tannin, resin, oils, &c. &c. But since the publication of this work, vegetable analysis has advanced to a degree of refinement which could scarcely have been anticipated in so short a period, and consequently many of his statements appear deficient; but his general directions for conducting an analysis of any vegetable substance, with a degree of accuracy sufficient for the views of the agriculturist, remain unimpeached.

The most valuable, and more strictly original part of this lecture, is his statement of the quantity of soluble or nutritive matters contained in varieties of the different substances that are used as articles of food, either for man or cattle, and which he has displayed in a tabular form.

The analyses were his own, and were conducted with a view to a knowledge of the general nature and quantity of the products, rather than to that of their intimate chemical composition. He proceeded upon the assumption that the excellence of the different articles, as food, will be in a great measure proportional to the quantities of soluble matters they afford; although he admits that these quantities cannot be regarded as *absolutely* denoting their value. Albuminous or glutinous matters have the characters of animal substances; sugar is more, and extractive matter less nourishing than any other principles composed of carbon, hydrogen, and oxygen. Certain combinations likewise of these substances may be more nutritive than others. There are some principles also, which although soluble in the vessels of the chemist, pass through the alimentary canal of animals without change; such is *tannin:* on the other hand, there are bodies which, although sparingly soluble in water, are readily acted upon by the gastric juice; *gluten* is a principle of this description.

Shortly after Dr. Wollaston published his scale of chemical equivalents, it occurred to me that by applying the sliding rule to a series of nutritive substances, arranged according to the analyses of Davy, some curious and important problems* might be solved; or at least, that the accuracy of the conclusions might be thus conveniently submitted to the test of practice. I accordingly superintended the construction of such an instrument, and submitted it to Davy, who expressed his approbation of the principle, but doubted how far the accuracy of his analyses would justify the experiment.

To such a scheme, however, I soon found that there existed a much more serious objection. The operation of the insoluble matter had been wholly neglected; and whatever views the chemist may entertain, the experience of the physiologist has established, beyond doubt, the influence of such matter in the process of digestion. The capacity of the alimentary organs of graminivorous animals sufficiently proves that they were designed for the reception of a *large bulk* of food, and not for provender in which the nutritive matter is concentrated; and since the gramineous and leguminous vegetables do not present this matter in a separate state, and the animal is not furnished with an apparatus by which he can remove it, the obvious inference is, that he was designed to feed indiscriminately upon the whole; and that, unless bulk be taken into the account, no fair inference can be deduced as to the nutritive value of different vegetables.

Notwithstanding the difficulties which prevent our arriving at any thing like an accurate conclusion upon so complicated a subject, the results may be received as affording some general views with regard to the comparative value of different nutritive vegetables. It would thus appear that at least a fourth part of the weight of the potatoe consists of nutritive matter, which is principally starch;—that wheat consists of as much as ninety-five, barley of ninety-two, oats of seventy-five, rye of eighty, and peas and beans of about fifty-seven per cent. of nutritive matter.

The FOURTH LECTURE comprises subjects of the utmost importance, and must be considered as constituting by far the most original and valuable division of the work. It treats of soils;—their constituent parts, their chemical

* For example:—What weight of wheat is equivalent to a given weight of oats, barley, rye, &c.? Suppose three hundred pounds of potatoes feed twenty head of cattle for any given time, how many will the same weight of oats feed?

analysis, their uses, their improvement, and of the rocks and strata found beneath their surface.

In the execution of this part of his labours, he has not only improved on the processes of Fordyce and Kirwan, but he has enriched the subject with much interesting and novel research.

" Soils, although extremely diversified in appearance and quality, consist of a comparatively few elements, which are in various states of chemical combination, or of mechanical mixture.

" These substances are silica, lime, alumina, magnesia, the oxides of iron, and of manganese; animal and vegetable matters in a state of decomposition; together with certain saline bodies, such as common salt, sulphate of magnesia, sometimes sulphate of iron, nitrates of lime and magnesia, sulphate of potash, and the carbonates of potash and soda.

" The silica in soils is usually combined with alumina and oxide of iron; or with alumina, lime, magnesia, and oxide of iron, forming gravel and sand of different degrees of fineness. The carbonate of lime is usually in an impalpable form; but sometimes in the state of calcareous sand. The magnesia, if not combined in the gravel and sand of the soil, is in a fine powder united to carbonic acid. The impalpable part of the soil, which is commonly called clay or loam, consists of silica, alumina, lime, and magnesia; and is, in fact, usually of the same composition as the hard sand, but more finely divided. The vegetable, or animal matters (and the first is by far the most common in soils,) exist in different states of decomposition. They are sometimes fibrous, sometimes entirely broken down and mixed with the soil.

" To form a just idea of soils, it is necessary to conceive different rocks decomposed, or ground into parts and powder of different degrees of fineness; some of their soluble parts dissolved by water, and that water adhering to the mass, and the whole mixed with larger or smaller quantities of the remains of vegetables and animals, in different stages of decay."

Soils then would appear to have been originally produced from the disintegration of rocks and strata; and hence there must be at least as many varieties of them, as there are species of rocks exposed at the surface of the earth; and they may be distinguished by names derived from the rocks from which they were formed; thus, if a fine red earth be found immediately above decomposing basalt, it may be denominated *basaltic* soil. If fragments of quartz and mica be found abundant, it may be denominated *granitic* soil; and the same principles may be extended to other analogous cases.

A general knowledge then of geology becomes essential to the scientific agriculturist, not only to enable him to form a correct judgment with respect to the connection between the varieties of soil and the subjacent rocks, but to direct him to the different mineral substances which may be associated together in their vicinity, and which may contain principles capable of extending their fertility, or of correcting the circumstances upon which their poverty or barrenness may depend.

With this conviction, Davy proceeds to offer a general view of the nature and position of rocks and strata in nature; but which, I confess, appears to me to be wholly useless to those who have any acquaintance with the subject, and far too meagre to convey any instruction to those who have not made this branch of science an object of study.

Upon this view, however, he has grounded a number of valuable remarks; although his observations appear to have been too limited to enable him to do justice to a subject of such extent and importance. Had he fulfilled his intention of making a survey of the county of Cornwall, the science must have been greatly advanced by his labours, for there is no district in Great Britain so rich in fact, and so capable of elucidating the history of soil, and the advantages of cultivation, when conducted on the principles of chemical philosophy. The soils superincumbent upon the different rocks are distinct and characteristic; and even in the same species varieties may be observed, in consequence of geological peculiarities. I have, for instance, found that the fertility of a granitic soil is encreased by the abundance of felspar in the parent rock;—that of a slaty soil by the degree of inclination or dip of the strata; but the most extraordinary circumstance perhaps connected with this subject, is the very remarkable fertility of the land which lies over the junction of these rocks,—so obvious indeed is it, that the eye alone is sufficient to trace it.

We are indebted to the author, in this lecture, for some very ingenious and important remarks on the relations of different soils to heat and moisture, and for a series of experiments by which his views are supported.

Some soils, he observes, are more easily heated, and more easily cooled than others: for example, those that consist principally of a stiff white clay are heated with difficulty; and being usually very moist, they retain their heat only for a short time. *Chalks* also are difficultly heated; but being dryer, they retain their heat longer, less being consumed in the process of evaporation.

A black soil, and those that contain much carbonaceous or ferruginous matter, acquire a higher temperature by exposure to the sun, than pale-coloured soils.

When soils are perfectly dry, those that most readily become heated, most rapidly cool; but the darkest-coloured dry soil, abounding in animal and vegetable matters, cools more slowly than a wet pale soil, composed entirely of earthy matter.

These results Davy gained by experiments made on different kinds of soils, exposed for a given time to the sun, and in the shade; the degrees of heating and cooling having been accurately ascertained by the thermometer.

Nothing can be more evident, than that the genial heat of the soil, particularly in spring, must be of the highest importance to the rising plant. And when the leaves are fully developed, the ground is shaded, and any injurious influence, which in the summer might be expected from too great a heat, entirely prevented; so that the temperature of the surface, when bare and exposed to the rays of the sun, affords at least one indication of the degree of its fertility; and the thermometer may therefore be sometimes a useful instrument to the purchaser or improver of lands.

Water is said to exist in soils, either in a state of chemical combination, or of cohesive attraction. It is in the latter state only that it can be absorbed by the roots of plants, unless in the case of the decomposition of animal and vegetable substances. The more divided the parts of the soil are, the greater is its attractive power for water; and the addition of vegetable and animal matters still farther increases this power.

The quality of soils to absorb water from air, is much connected with fertility. Davy informs us that he has compared this absorbent power in numerous instances, and that he always found it greatest in the most productive lands: he states, however, the important fact, that those soils, such for instance as stiff clays, which take up the greatest quantity of water, when it is poured upon them in a fluid form, are not such as absorb most moisture from the atmosphere in dry weather. They cake, and present only a small surface to the air, and the vegetation on them is generally burnt up almost as readily as on sands.

There is probably no district in which the importance of moisture in relation to fertility is more apparent than in Cornwall; and there is a provincial saying, that the land will bear a shower every week-day, and two upon a Sunday; indeed, of such importance is moisture, that it is by no means an uncommon practice to encourage the growth of weeds, in order to diminish the evaporation; a necessity which arises from the excess of siliceous matter in the soil.

To those who are disposed to prosecute this enquiry, I should recommend a perusal of Mr. Leslie's treatise on the "Relations of Air to Heat and Moisture."

I must not quit the consideration of this lecture, without adverting to the directions with which its author has furnished the philosophical farmer for analysing the different varieties of soil; and which are so clear, so perfect, and above all so simple, that they are now introduced into all elementary works on chemistry, as the only guide to such researches. His method for ascertaining the quantity of carbonate of lime in any specimen, consists in determining the loss of weight which takes place on its admixture with muriatic acid; for since carbonate of lime, in all its states, contains a determinate proportion of carbonic acid, it is evident that, by estimating the quantity of elastic matter given out, the proportion of carbonate of lime will be known. For conducting this experiment, he contrived a very simple and ingenious piece of pneumatic apparatus, in which the bulk of the carbonic acid is at once measured by the quantity of water it displaces.

In his Fifth Lecture he enters upon the nature of the atmosphere, and its influence on vegetables: he also examines the process of the germination of seeds, and the functions of plants in their different stages of growth; and concludes with a general view of the progress of vegetation.

I shall merely mention a few of the more interesting points in this enquiry.

In illustrating the importance of water to the vegetable creation, he observes that the atmosphere always contains water in its elastic and invisible form; the quantity of which will vary with the temperature. In proportion as the weather is hotter, the quantity is greater; and it is its condensation by diminution of temperature, which gives rise to the phenomena of dew and mist. The leaves of living plants appear to act upon this vapour, and to absorb it. Some vegetables increase in weight from this cause, when suspended in the atmosphere, and unconnected with the soil; such are the houseleek, and different species of the aloe. In very intense heats, and when the soil is dry, the life of plants seems to be preserved by the absorbent powers of their leaves; and it is a beautiful circumstance in the economy of nature, that aqueous vapour is most abundant in the atmosphere when it is most needed for the purposes of life; and that when other sources of its supply are cut off, this is most copious.*

If water in its elastic and fluid states be essentially necessary to the economy of vegetation, so even in its solid form, it is not without its uses. Snow and ice are bad conductors of heat; and at a period when the severity of the winter threatens the extinction of vegetable life, Nature kindly throws her snowy mantle over the surface; while in early spring the solution of the snow becomes the first nourishment of the plant; at the same time, the expansion of water in the act of congelation, and the subsequent contraction of its bulk during a thaw, tend to pulverise the soil, to separate its parts from each other, and, by making it more permeable to the influence of the air, to prepare it for the offices it is destined to perform.

He next proceeds to consider the action of the atmosphere on plants, and to connect it with a general view of the progress of vegetation. He commences with examining its relations to germination.

"If a healthy seed be moistened and exposed to air at a temperature not below 45°, it soon germinates, it shoots forth a *plume* which rises upwards, and a *radicle* which descends.

"If the air be confined, it is found that, in the process of germination, the oxygen, or a part of it, is absorbed. The azote remains unaltered; no carbonic acid is taken away from the air; on the contrary, some is added." Upon this point, critics have been disposed to break a lance with Sir Humphry. The doctrine, let it be observed, is at variance with the numerous experiments made on this subject by Scheele, Cruickshank, and De Saussure; the results of which agree in proving, that if seeds be confined and made to germinate in a given portion of air, not a *part* only, but the *whole* of the oxygen is consumed; and that its place is supplied, not merely by *some*, but by an *equal bulk* of carbonic acid.

* The history of his native county would have furnished him with a parallel instance of the intelligence and design which Nature displays in connecting the wants and necessities of the different parts of creation, with the power and means of supplying them. In a primitive country like Cornwall, the siliceous soil necessarily requires much moisture, and we may perceive that the cause which occasions, at the same time supplies this want; for the rocks elevated above the surface, solicit a tribute from every passing cloud, while in alluvial and flat districts, where the soil is rich, deep, and retentive of moisture, the clouds float undisturbed over the plains, and the country frequently enjoys that uninterrupted series of dry weather which is so necessary to its fertility. Linnæus observes, that the plants which chiefly grow upon the summit of mountains, are rarely found in any other situation, except in marshes, because the clouds arrested in their progress by such elevations, keep the air in a state of perpetual moisture.

Objections have been also started to his theory of the chemical changes which the seed undergoes during the process of germination: but were I to enter upon these discussions, time and space would alike fail me, to say nothing of the patience of the reader, which would be exhausted long before we could arrive at any satisfactory conclusion. I shall for the same reasons pass over his observations upon the influence exerted upon growing plants on the air: the subject is involved in much difficulty, which can be only removed by fresh experiments; nor, after all, is the great question, whether the purity of the atmosphere is maintained by vegetation, of any practical moment,—it is one which partakes more of curiosity than of use, and might therefore have been well dispensed with in a system of agriculture.

He agrees with many other philosophers in considering "the process of malting as merely one in which germination is artificially produced, and in which the starch is changed into sugar; which sugar is afterwards, by fermentation, converted into spirit.

"It is," he continues, "very evident from the chemical principles of germination, that the process should be carried on no farther than to produce the sprouting of the radicle, and should be checked as soon as this has made its distinct appearance. If it is pushed to such a degree as to occasion the perfect developement of the radicle and the plume, a considerable quantity of saccharine matter will have been consumed in producing their expansion, and there will be less spirit formed in fermentation, or produced in distillation.

"As this circumstance is of some importance, I made, in October 1806, an experiment relating to it. I ascertained by the action of alcohol, the relative proportions of saccharine matter in two equal quantities of the same barley; in one of which the germination had proceeded so far as to occasion protrusion of the radicle to nearly a quarter of an inch beyond the grain in most of the specimens, and in the other of which it had been checked before the radicle was a line in length; the quantity of sugar afforded by the last was to that in the first nearly as six to five."

The whole of this subject appears to be debateable ground between the physiologists and chemists; the one considering the change of starch into sugar as the result of the vital action of the seed; the other affirming that the growth of the germ is in no way necessary to the result, and is to be considered as a mere indication of the due degree of change being effected in the organic matter, or, in other words, that when the organized parts exhibit a certain degree of developement, then the inorganic matter is most completely changed. All growth beyond this is injurious, as leading to a consumption of the inorganic matter. All less than this is not otherwise disadvantageous, than as an indication that the inorganic matter is not duly changed. This change, it is farther affirmed, so far from depending upon vegetable life, can be wrought on the matter of the seed after it is even reduced to powder, or is separated in the form of starch. At all events, it must be admitted as a beautiful arrangement in nature, that the same agents which urge on the developement of the organized parts, should, at the same time, assist in preparing food for their support.

From this subject Davy is very naturally led to the consideration of the ravages inflicted upon the infant plant by insects; the saccharine matter in the cotyledons at the time of their change into seed-leaves, rendering them exceedingly liable to such attacks. He appears to have bestowed much attention on the turnip-fly, a colyopterous insect, which fixes itself upon the seed-leaves of the turnip at the time that they are beginning to perform their functions. He relates the several remedies which have been proposed for this evil; and from letters which have been put in my possession, addressed to Dr. Cartwright as early as the year 1804, he appears to have been engaged with that gentleman in experiments made by sprinkling the young plants with lime and urine.

After alluding to the parasitical plants of different species, which attach themselves to trees and shrubs, feed on their juices, destroy their health, and finally their life, for which, at present, there does not exist any remedy, he thus concludes his lecture:

"To enumerate all the animal destroyers, and tyrants of the vegetable kingdom, would be to give a catalogue of the greater number of the classes in Zoology. Every species of plant almost is the peculiar resting-place, or dominion, of some insect tribe; and from the locust, the caterpillar, and snail, to the minute aphis, a wonderful variety of the inferior insects are nourished, and live by their ravages upon the vegetable world.

"The Hessian fly, still more destructive to wheat than the one which ravages the turnip plant, has in some seasons threatened the United States with a famine. And the French government is at this time* issuing decrees with a view to occasion the destruction of the larvæ of the grasshopper.

"In general, wet weather is most favourable to the propagation of mildew, funguses, rust, and the small parasitical vegetables; dry weather to the in-

* January 1813.

crease of the insect tribes. Nature, amidst all her changes, is continually directing her resources towards the production and multiplication of life; and in the wise and grand economy of the whole system, even the agents that appear injurious to the hopes, and destructive to the comforts of man, are in fact ultimately connected with a more exalted state of his powers and his condition. His industry is awakened, his activity kept alive, even by the defects of climates and season. By the accidents which interfere with his efforts, he is made to exert his talents, to look farther into futurity, and to consider the vegetable kingdom, not as a secure and unalterable inheritance, spontaneously providing for his wants; but as a doubtful and insecure possession, to be preserved only by labour, and extended and perfected by ingenuity."

His Sixth Lecture treats of manures of animal and vegetable origin, and of the general principles with respect to their uses and modes of application.

It is evident that plants, by their growth, must gradually exhaust the soil of its richer and more nutrient parts; and these can be alone restored by the application of manures. It is equally obvious, that if a soil be sterile from any defect in its constitution, such a defect can be only remedied by artificial additions. Hence the introduction of foreign matter into the earth, for the purpose of accelerating vegetation, and of increasing the produce of its crops, is a practice which has been pursued since the earliest period of agriculture. Unfortunately, however, the greatest ignorance has prevailed in all ages with regard to the best modes of rendering such a resource available; and the farmer, instead of enriching the soil, has too frequently given his treasures to the winds. "It is quite lamentable," says an intelligent writer,* "to survey a farm-yard in many parts of the kingdom; to see the abundance of vegetable matter that is trodden for months under foot, over a surface of perhaps half an acre of land, exposed to all the rains that fall, by which its more soluble and richer parts are washed away, or perhaps carried down to poison the water of some stagnant pool, which the unfortunate cattle are afterwards compelled to drink. From the yard, the manure is often carted to the field, at the time when the land is rendered impenetrable by frost; or, if this operation be delayed to a less unseasonable period, it is then frequently laid down in small heaps, or sometimes spread over the surface, exposed for many days to the sun, the winds, and the rain, as if with the direct design of dissipating those more volatile parts which it ought to be the farmer's first endeavour to preserve.

* Edinburgh Review, vol. xxii. p. 270.

" Nothing can be so likely to remove ignorance so deplorable, and prejudices so inveterate, as the diffusion of real knowledge concerning the nature of manures, and their mode of action on soils, and on the plants which grow in them."

Davy, fully sensible of the practical importance of the subject, and impressed with the conviction that it was capable of being materially elucidated by the recent discoveries of chemistry, determined to put forth his strength, in order to bring this department of agriculture under the dominion of science; and upon this occasion our philosopher presents himself in the only character in which he ever ought to appear—in that of an original experimentalist.

His first step in the enquiry was to ascertain whether solid substances can pass from the soil through the minute pores in the fibres of the root. He tried an experiment by introducing a growing plant of peppermint into water which held in suspension a quantity of impalpably powdered charcoal: but after a fortnight, upon cutting through different parts of the roots, no carbonaceous matter could be discovered in them, nor were the smallest fibres even blackened, though this must have happened, had the charcoal been absorbed in a solid form. If a substance so essential to plants as carbonaceous matter, cannot be introduced except in a state of solution into their organs, he very justly concludes that other less essential bodies must be in the same case.

He also proved by experiment that solutions of sugar, mucilage, jelly, and other principles, unless considerably diluted, clogged up the vegetable organs with solid matter, and prevented the transpiration by the leaves; when, however, this precaution was taken, the plants grew most luxuriantly in such liquids.

He next proceeded to determine whether soluble vegetable substances passed in an unchanged state into the roots of plants, by comparing the products of the analysis of the roots of plants of mint which had grown, some in common water, some in a solution of sugar: the results favoured the opinion that they were so absorbed. It appeared moreover, that substances even poisonous to vegetables did not offer an objection to this law. He introduced the roots of a primrose into a weak solution of oxide of iron in vinegar, and suffered them to remain in it till the leaves became yellow; the roots were then carefully washed in distilled water, bruised, and boiled in a small quantity of the same fluid; the decoction of them passed through a filtre was examined, and found to contain iron; so that this metal must have been taken up by the vessels or pores in the root.

If to these facts are added those connected with the changes which animal and vegetable substances undergo by the process of putrefaction, we have all the data necessary for forming a rational theory, to guide us in the management and application of manures.

Davy has very satisfactorily shown the cases in which putrefaction or fermentation should be encouraged, and avoided. As a general rule, it may be stated, that when manure consists principally of matter soluble in water, its fermentation or putrefaction should be prevented as much as possible; but on the contrary, when it contains a large proportion of vegetable or animal fibre, such processes become necessary.

To prevent manures from decomposing, he recommends that they should be preserved dry, defended from the contact of the air, and kept as cool as possible. Salt and alcohol, he observes, appear to owe their powers of preserving animal and vegetable substances to their attraction for water, by which they prevent its decomposing action, and likewise to their excluding air. The importance of this latter circumstance he illustrates by the success of M. Appart's method of preserving meat.

By allowing the fermentation of manure to proceed beneath the soil, rather than in the farm-yard, we not only preserve elements which would otherwise be dissipated, but we obtain several incidental advantages; for example, the production of *heat*, which is useful in promoting the germination of the seed; this must be particularly favourable to the wheat crop, in preserving a genial temperature beneath the surface late in autumn, and during winter.

Again:—it is a general principle in chemistry, that in all cases of decomposition, substances combine much more readily at the moment of their disengagement, than after they have been perfectly formed. And in fermentation beneath the soil, the fluid matter produced is applied instantly, even whilst it is warm, to the organs of the plant, and consequently is more likely to be efficient than in manure that has gone through the process, and of which all the principles have already entered into new combinations.

He examines with much attention the various animal and vegetable matters which have been used as manure, and furnishes the farmer with a number of practical remarks on their nature and mode of operation. For these, the reader must refer to the work itself; for my limits will not allow me to enter into the consideration of *rape-cake—malt-dust—linseed-cake—sea-weeds—peat—wood-ashes—fish—bones—hair, woollen rags, and feathers—blood,* &c. &c.; to each of which he assigns peculiar qualities and virtues.

As he regards the due regulation of the fermentative process of the utmost importance, he has furnished some valuable hints for the conduct of the farmer upon this occasion. He considers that a compact marle, or a tenacious clay, offers the best protection against the air; and before the dung is covered over, or, as it were, sealed up, he recommends that it should be dried as much as possible. If at any time it should heat strongly, he advises the farmer to turn it over, and thus cool it by exposure to the air; for the practice sometimes adopted of watering dunghills, is inconsistent with just chemical views. It may cool the dung for a short time; but moisture, it will be remembered, is a principal agent in all processes of decomposition.

In cases of the fermentation of dung, there are simple tests by which the rapidity of the process, and consequently the injury done, may be discovered. If, for instance, a thermometer plunged into the mass does not rise above 100°, it may be concluded that there is not much danger of the escape of aëriform matter; but should it exceed this, the dung ought to be immediately spread abroad.

When a piece of paper moistened in muriatic acid, held over the steams arising from a dung-hill, gives dense fumes, it is a certain test that the decomposition is going too far; for this indicates that volatile alkali is disengaged.

It may be truly said that, under the hand of Davy, the coldest realities blossomed into poetry: the concluding passage of this lecture certainly sanctions such an opinion, and is highly characteristic of that peculiar genius to which I have before alluded.* A subject less calculated than a heap of manure to call forth a glowing sentiment, can scarcely be imagined.

" The doctrine," says he, " of the proper application of manures from organized substances, offers an illustration of an important part of the economy of nature, and of the happy order in which it is arranged. The death and decay of animal substances tend to resolve organized forms into chemical constituents; and the pernicious effluvia disengaged in the process seem to point out the propriety of burying them in the soil, where they are fitted to become the food of vegetables. The fermentation and putrefaction of organized substances in the free atmosphere are noxious processes; beneath the surface of the ground they are salutary operations. In this case the food of plants is prepared where it can be used; and that which would offend the senses, and injure the health, if exposed, is converted by gradual processes into forms of beauty and of usefulness; the fetid gas is rendered a constituent of the aroma

* Page 123.

of the flower, and what might be poison, becomes nourishment to man and animals."

The Seventh Lecture is devoted to the investigation of manures of a mineral origin. He commences the subject by refuting the opinion of Schrader and Braconnot, that the different earthy and saline substances found in plants arise from new arrangements of the elements of air and water, by the agencies of their living organs.

In 1801, he made an experiment on the growth of oats, supplied with a limited quantity of distilled water, in a soil composed of pure carbonate of lime. The soil and the water were placed in a vessel of iron, which was included in a large jar, connected with the free atmosphere by a tube, so curved as to prevent the possibility of any dust, or fluid, or solid matter, from entering into the jar. His object was to ascertain whether any siliceous earth would be formed in the process of vegetation; but the oats grew very feebly, and began to be yellow before any flowers formed. The entire plants were burnt, and their ashes compared with those from an equal number of grains of oat. Less siliceous earth was given by the plants than by the grains; but their ashes yielded much more carbonate of lime.

Numerous other authorities might be quoted to the same effect. Jacquin states that the ashes of Glass-wort, (*Salsola-Soda*) when it grows in inland situations, afford the vegetable alkali; but when on the sea-shore, the fossile or mineral alkali. Du Hamel also found, that plants which usually grow on the sea-shore, made small progress when planted in soils containing little common salt. The Sunflower, when growing on lands not containing nitre, does not afford that substance; though when watered by its solution, it yields nitre abundantly. De Saussure made plants grow in solutions of different salts; and he ascertained that, in all cases, certain portions of the salts were absorbed by the plant, and found unaltered in their organs.

It may be admitted then as established, that the mineral principles found in plants are derived from the soils in which they vegetate. This fact becomes the foundation of the theory respecting the operation of mineral manure.

Davy observes, that "the only substances which can with propriety be called fossile manures, and which are found unmixed with the remains of any organized beings, are certain alkaline earths, or alkalies, and their combinations." If he intends to limit the term to those bodies only which find their way into the structure of plants, his definition may be correct; but I am inclined to take a much wider view of the subject; and to include all those mineral substances which promote vegetation by modifying the texture of the soil:—but of this hereafter.

Lime, not only from its importance, but from the controversies which it has occasioned, ranks first in the list of mineral manures.

That disputes concerning the uses of lime and its carbonate, should have long existed, and be still continued amongst a class of persons who, whatever may be their practical knowledge, are not acquainted with the composition of the substances about which they differ, is certainly by no means extraordinary. Davy, therefore, very properly introduces the subject, by a description of the nature and qualities of these bodies, and by marking the distinctions between quick-lime and its carbonate.

The substance commonly known by the name of *Limestone,* is a compound of lime and carbonic acid, associated generally with other earthy bodies, the nature and proportions of which vary in different species. "When a limestone does not copiously effervesce in acids, and is sufficiently hard to scratch glass, it contains siliceous, and probably aluminous earth. When it is deep brown or red, or strongly coloured of any of the shades of brown or yellow, it contains oxide of iron: when it is not sufficiently hard to scratch glass, but effervesces slowly, and makes the dilute nitric acid in which it effervesces milky, it contains magnesia; and when it is black, and emits a fetid smell if rubbed, it contains coally, or bituminous matter."

As the agricultural value of limestone is materially modified by the substances with which it may be associated, their analysis becomes an object of much importance, and the author has accordingly proposed a simple method of effecting it.

Before any opinion can be formed of the manner in which these different ingredients operate, it is necessary that the action of the pure calcareous element as a manure should be thoroughly understood.

In its caustic state, whether used in powder, or dissolved in water, lime is injurious to plants. Davy informs us that he has, in several instances, killed grass by watering it with lime water; but in its combination with carbonic acid, it is an useful ingredient in soils.

When newly-burnt lime is exposed to the atmosphere, it soon falls into powder, from uniting with the moisture of the air; and the same effect is immediately produced by throwing water upon it, when it heats violently, and the water disappears: in this state it is commonly called *slacked* lime: chemists have named it the *hydrat* of lime; and when this hydrat becomes a carbonate, by long exposure to the air, its water is in part expelled, and the carbonic acid takes its place.

Lime, whether freshly burnt, or slacked, acts powerfully on moist fibrous vegetable matters, and forms with them a compost, of which a part is usually soluble in water. By this operation, it renders inert vegetable matter active; and as charcoal and oxygen (the elements of carbonic acid) abound in vegetables, it is itself, at the same time, converted into a carbonate. But limestone simply powdered, marls, or chalks, do not thus act on vegetable matter; and hence the operation of quicklime and mild lime depends on principles altogether different. Quicklime acts on any hard vegetable matter, so as to render it more readily soluble; the mild limes, or carbonates, act only by improving the texture of the soil, or of supplying a due proportion of calcareous matter: thus almost all soils which do not effervesce with acids, are improved by mild lime and sand, more than clays. I apprehend that it is upon this principle the application of shelly sand proves beneficial in Cornwall, although I have ascertained that, on some occasion, its value depends upon its chemical action upon mineral bodies in the soil.

Soils abounding in soluble vegetable manures are injured by quicklime, as it tends to decompose their soluble matters, or to form with them compounds less soluble than the pure vegetable substance. With animal manures, it is equally exceptionable, unless indeed they be too rich, or it becomes necessary to prevent noxious effluvia; for since it decomposes them, it destroys their efficacy, and tends to render the extractive matter insoluble.

The limestones containing alumina and silex are less fitted for the purposes of manure than pure limestones; but the lime formed from them has no noxious quality. Such stones are less efficacious, merely because they furnish a smaller quantity of quicklime. Those, however, that contain magnesia, if indiscreetly used, may be very detrimental.

It had been long known to farmers in the neighbourhood of Doncaster, that lime made from a certain limestone, when applied to the land, often injured the crops considerably. Mr. Tennant discovered that this limestone contained magnesia; and on mixing some calcined magnesia with soil, in which he sowed different seeds, he found that they either died, or very imperfectly vegetated; and with great justice and ingenuity, he referred the bad effects of the peculiar limestone to the magnesian earth it contained. In prosecuting the enquiry, Davy however ascertained that there were cases in which this magnesian lime was used with good effect,—in small quantities, for example, on rich land: and during his chemical consideration of the question, he was led to the following satisfactory solution.

"Magnesia has a much weaker attraction for carbonic acid than lime, and will remain in the state of caustic or calcined magnesia for many months, though exposed to the air; and as long as any caustic lime remains, the magnesia cannot be combined with carbonic acid, for lime instantly attracts carbonic acid from magnesia. When therefore a magnesian limestone is burnt, the magnesia is deprived of its carbonic acid much sooner than the lime, and in this state it is a poison to plants. That more magnesian lime may be used upon rich soils,* seems to be owing to the circumstance, that the decomposition of the manure in them supplies carbonic acid, and thus converts it into a mild carbonate. Besides being used in the forms of lime and carbonate of lime, calcareous matter is applied for the purposes of agriculture in other combinations. The principal body of this kind is *gypsum*, or sulphate of lime; respecting the uses and operation of which very discordant opinions have been formed.

Its beneficial operation has been referred to two causes, viz. to its power of attracting moisture from the air, or to its assisting the putrefaction of animal substances; but Davy has shown by experiments that neither of these theories can be supported by facts.

The most extraordinary circumstance perhaps connected with the history of this mineral manure, is the very opposite opinions which have been formed respecting its value. In this country, although there are various testimonies in its favour, it has never been employed with the signal success which marked its adoption in America, and which was so palpable and extraordinary as at once to have ensured its universal introduction.

I was some years since assured by Mr. Maclure of Philadelphia, that whenever any doubt or hesitation betrayed itself with respect to its fertilizing

* These facts have been confirmed by agriculturists, who could not possibly have had any favourite theory to support. Dr. Fenwick tells us, (Essay on Calcareous Manures, p. 11. 1798,) that in the county of Durham, the farmers always distinguish between *hot* and *mild* limes. They never apply the former to exhausted lands, or to any soil that has been long under a course of tillage, unless it be very deep and rich. In peaty soils, and in new, sour, and wild lands, the *hot* limes, on the contrary, are preferred to the *mild* ones. Dr. Fenwick made some experiments to ascertain the cause of the differences between these varieties of lime; and though he failed to discover that by analysis which Mr. Tennant subsequently ascertained, he nevertheless arrived at a just conclusion by simple observation; and was led to believe, that "what farmers term *hot* limes, are such as re-absorb their fixed air more slowly, and therefore continue longer to exert the peculiar action of quicklime."

agency, it was only necessary to sprinkle a small quantity in a meadow to satisfy the most sceptical; and that this was usually done in the form of letters or characters, which in a short time became so much more luxuriant than the surrounding grass, as to be visible at a considerable distance. It is, I understand, chiefly applied to grass lands as a *top dressing;* and the American farmers * explain its operation upon its solubility in water, and its consequent absorption by the roots of the grass. Davy, in examining the ashes of sainfoin, clover, and rye grass, which had grown in soils manured by gypsum, found considerable quantities of that substance; and he thinks it probable that it was intimately connected with their woody fibre. He attempts to explain the reason why the application of gypsum is not generally efficacious, by supposing that most of the cultivated soils may already contain it in sufficient quantities for the use of the grasses. I strongly suspect, however, that it will be hereafter discovered to depend upon the nature of the soil in its hygrometric relations. From the facts already recorded, it would appear that it never answers near the sea, nor in wet lands. In consequence of its solubility, it is enabled to penetrate and pervade the whole vegetable structure; and the experiments of Davy have proved its presence in the ashes of plants exposed to its operation, and have rendered it probable that it enters into union with their woody fibre, by which the density of their textures will be increased, and consequently the evaporation from their leaves diminished; I am from such considerations induced to think that gypsum does not act by effecting any chemical change in the soil, but solely by diminishing the plant's evaporation. This idea seems to be borne out by the evidence furnished by the different circumstances attending the operation of this manure: we find, for example, that succulent vegetables, planted on dry soils, are those which are principally benefited by its application, and that the various grasses so

* When this substance was first introduced into America, which is nearly forty years since, it was imported from the quarries of Montmartre, and in such request was it, that a bushel of wheat was usually given for the same measure of gypsum: it is now, I believe, obtained from Nova Scotia; I have not heard that it has been found within the States. It may perhaps serve to convey some idea of the extent to which it has been applied, when I state, that Mr. Maclure assured me that not less than three hundred vessels are constantly employed in the traffic, and that in Philadelphia twenty merchants, at least, are engaged in supplying the demand for it. Its efficacy appears to be considerably increased by applying it in a minute state of division; and a want of attention to this circumstance may possibly have been one of the causes which have rendered its advantages less conspicuous in England. In America, three or four hundred mills, of a peculiar construction, have been erected in different parts for the purpose of grinding it.

manured retain their verdure, even in the dryest season and on the most arid lands; at the same time, we find that these crops, especially clover, acquire a proportionate increase in the density of their fibres, that is to say, that they become much more rank and stubborn, and often to such a degree does this take place, that in America, where its effects are best understood, sheep not uncommonly refuse to feed upon them. Upon the same principle we find that, under circumstances or in situations where the evaporation of a plant is provided for by a constant supply of moisture, the effects of gypsum cease to be apparent.

Davy hints at a process by which gypsum may be formed in a soil containing sulphate of iron, by the action of calcareous manure,* and which was first pointed out by Dr. Pearson. I can confirm this statement by the results of experiments I formerly made in Cornwall, where soil containing this salt of iron had been manured by shelly sand.

In pursuing his enquiry into the efficacy of mineral manure, Davy proceeds to investigate the efficacy of the fixed alkalies, and observes that their general tendency is to give solubility to vegetable matters, and in this way to render carbonaceous and other substances capable of being taken up by the tubes in the radicle fibres of plants. The vegetable alkali has likewise a strong attraction for water, and even in small quantities may tend to give a due degree of moisture to the soil, or to other manures.

He considers that pure salt may act, like gypsum, phosphate of lime, and the alkalies, by entering into the composition of the plant. Upon the subject of salt, however, his remarks are very meagre and unsatisfactory: at the time he composed his lecture, the subject had not excited that public attention which the writings of Mr. Parkes, Sir Thomas Bernard, and others have since awakened.

Had our philosopher undertaken the agricultural survey of Cornwall, his lecture on mineral manure must have been very considerably extended. He would have learnt that various rocks reduced to small fragments, are commonly applied as dressing; he would have explained the cause of the fertility so generally associated with hornblende rocks;—he would have speculated upon the influence of iron in giving fruitfulness; and above all, he would have taught the agriculturist the scientific use of calcareous sand, by pointing out

* Gypsum is readily produced by the admixture of decomposing pyrites and calcareous matter; in proof of which the Mineralogist can produce specimens of oyster shells studded with crystals of selenite from Shotover; and alum from the *aluminous shale* at the Hurlet Mine near Glasgow.

the description of lands which are most likely to be benefited by its application.

The Eighth Lecture concludes the subject of the chemistry of agriculture, by establishing the theory of the operation of burning lands: he considers the process to be useful in rendering the soil less compact, and less tenacious and retentive of moisture; and that, when properly applied, as being capable of converting a matter that was stiff, damp, and cold, into one powdery, dry, and warm, and much more proper as a bed for vegetable life. He states the great objection made by speculative chemists to paring and burning, to be the unavoidable destruction of vegetable and animal matter, or the manure of the soil; but he considers that, in those cases in which the texture of its earthy ingredients is permanently improved, there is more than a compensation for so temporary a disadvantage; and that in some soils, where there is an excess of inert vegetable matter, the destruction of it must be beneficial, and that the carbonaceous matter remaining in the ashes may be more useful to the crop than the vegetable fibre from which it was produced.

In this view of the subject it is evident, that all poor siliceous sands must be injured by the operation; "and here," says Davy, "practice is found to accord with theory. Mr. Arthur Young, in his Essay on Manures, states, 'that he found burning injure sand;' and the operation is never performed by good agriculturists upon siliceous sandy soils, after they have been once brought into cultivation. An intelligent farmer in Mount's Bay told me, that he had pared and burned a small field several years ago, which he had not been able to bring again into good condition. I examined the spot,—the grass was very poor and scanty, and the soil an arid siliceous sand." *Irrigation*, or *watering land*, is a practice, he observes, which at first view appears the reverse of torrefaction; and, in general, the operation of water in nature is to bring earthy substances into an extreme state of division. But in the artificial watering of meadows, the beneficial effects may depend upon many different causes, some chemical, some mechanical. It may act as a simple supply of moisture to the roots, or it may carry into the soil foreign matter, or diffuse that which exists in it more equally through its substance.

He concludes with some valuable scientific observations upon the process of *fallowing*, by which he attempts to correct the prejudices which have existed with regard to its benefits. He points out, on the other hand, the great advantages of the convertible system of husbandry, by which the whole of the manure is employed; and those parts of it which are not fitted for one crop, remain as nourishment for another. These views he illustrates by a reference to the course of crops adopted by Mr. Coke, in which "the turnip is the first in the order of succession; and this crop is manured with recent dung, which immediately affords sufficient soluble matter for its nourishment; and the heat produced in fermentation assists the germination of the seed and the growth of the plant. After turnips, barley with grass seeds is sown; and the land having been little exhausted by the turnip crop, affords the soluble parts of the decomposing manure to the grain. The grasses, rye-grass, and clover remain, which derive a small part only of their organized matter from the soil, and probably consume the gypsum in the manure which would be useless to other crops: these plants likewise, by their large system of leaves, absorb a considerable quantity of nourishment from the atmosphere, and when ploughed in at the end of two years, the decay of their roots and leaves affords manure for the wheat crop; and at this period of the course, the woody fibre of the farm-yard manure, which contains the phosphate of lime and the other difficultly soluble parts, is broken down; and as soon as the most exhausting crop is taken, recent manure is again supplied."

At the end of his system is added an Appendix, containing An Account of the results of experiments on the produce and nutritive qualities of the grasses and other plants used as the food of animals; instituted by John Duke of Bedford." But as these experiments do not admit either of abridgement or analysis, the reader must refer to the original source for information.

I shall conclude this long, and I fear somewhat tedious review, with the animated appeal so earnestly addressed by the illustrious author to the philosophical readers of his work.

"I trust that the enquiry will be pursued by others; and that in proportion as chemical philosophy advances towards perfection, it will afford new aids to agriculture; there are sufficient motives connected both with pleasure and profit, to encourage ingenious men to pursue this new path of investigation. Science cannot long be despised by any persons as the mere speculation of theorists, but must soon be considered by all ranks of men in its true point of view, as the refinement of common sense guided by experience, gradually substituting sound and rational principles for vague popular prejudices.

"The soil offers inexhaustible resources, which, when properly appreciated and employed, must increase our wealth, our population, and our physical strength.

"We possess advantages in the use of machinery, and the division of labour, belonging to no other nation. And the same energy of character, the same extent of resources, which have always distinguished the people of the British Islands, and made them excel in arms, commerce, letters, and philosophy, apply with the happiest effects to the improvement of the cultivation of the earth. Nothing is impossible to labour, aided by ingenuity. The true objects of the agriculturist are likewise those of the patriot. Men value most what they have gained with effort; a just confidence in their own powers results from success; they love their country better, because they have seen it improved by their own talents and industry; and they identify with their interests, the existence of those institutions which have afforded them security, independence, and the multiplied enjoyments of civilized life."

CHAPTER X.

Mr. Faraday's introduction to Sir H. Davy.—A renewed correspondence on the subject of the Gunpowder Manufactory.—Davy obtains permission from Napoleon to visit the Continent.—He embarks in a Cartel from Plymouth.—Is arrested at Morlaix.—Arrives at Paris.—Visits the Louvre.—His extraordinary conduct upon that occasion.—Inspects the Colossal Elephant, and is introduced to M. Alavair, its architect.—The discovery of the dungeons of the Bastile.—Davy's interesting letter to M. Alavair.—He attends a meeting of the Institute.—Is visited by all the principal savans of Paris.—The adventure which befell Lady Davy in the Thuilleries' Garden.—Anniversary dinner of the Philomatic Society.—The junior Chemists of France invite Davy to a splendid entertainment.—How far Davy is entitled to be considered the discoverer of the true nature of Iodine.—Napoleon's unlucky experiment with the Voltaic battery.—Davy is presented to the Empress Josephine.—An account of the Court ceremony at Malmaison.—Remarks on the conduct of Davy during his visit to Paris.—He quits the capital of France, and proceeds, by way of Lyons, to Montpellier.—Is assisted in experiments on sea-weed by M. Berard.—Crosses the Alps.—Arrives at Genoa.—Institutes experiments on the Torpedo.—Visits Florence, and accomplishes the combustion of the diamond, by the great lens in the cabinet of Natural History.—Experiments on Iodine.—He examines the colours used by the Ancients.—Visits all the celebrated Philosophers of Italy and Switzerland, with whom he works in their laboratories.—Returns to England.

It is said of Bergman, that he considered the greatest of his discoveries to have been the discovery of Scheele.* Amongst the numerous services conferred upon Science by Sir Humphry Davy, we must not pass unnoticed that kind and generous patronage which first raised Mr. Faraday from obscurity, and gave to the chemical world a philosopher capable of pursuing that brilliant path of enquiry which the genius of his master had so successfully explored.

The circumstances which first led Mr. Faraday to the study of chemistry, and by which he became connected with the Royal Institution, were communicated to me, by himself, in the following letter.

* See Note at page 31.

TO J. A. PARIS, M. D.

MY DEAR SIR, Royal Institution, Dec. 23, 1829.

You asked me to give you an account of my first introduction to Sir H. Davy, which I am very happy to do, as I think the circumstances will bear testimony to his goodness of heart.

When I was a bookseller's apprentice, I was very fond of experiment, and very averse to trade. It happened that a gentleman, a member of the Royal Institution, took me to hear some of Sir H. Davy's last lectures in Albemarle Street. I took notes, and afterwards wrote them out more fairly in a quarto volume.

My desire to escape from trade, which I thought vicious and selfish, and to enter into the service of Science, which I imagined made its pursuers amiable and liberal, induced me at last to take the bold and simple step of writing to Sir H. Davy, expressing my wishes, and a hope that, if an opportunity came in his way, he would favour my views; at the same time, I sent the notes I had taken at his lectures.

The answer, which makes all the point of my communication, I send you in the original, requesting you to take great care of it, and to let me have it back, for you may imagine how much I value it.

You will observe that this took place at the end of the year 1812, and early in 1813 he requested to see me, and told me of the situation of assistant in the Laboratory of the Royal Institution, then just vacant.

At the same time that he thus gratified my desires as to scientific employment, he still advised me not to give up the prospects I had before me, telling me that Science was a harsh mistress; and, in a pecuniary point of view, but poorly rewarding those who devoted themselves to her service. He smiled at my notion of the superior moral feelings of philosophic men, and said he would leave me to the experience of a few years to set me right on that matter.

Finally, through his good efforts I went to the Royal Institution early in March of 1813, as assistant in the Laboratory; and in October of the same year, went with him abroad as his assistant in experiments and in writing. I returned with him in April 1815, resumed my station in the Royal Institution, and have, as you know, ever since remained there.

I am, dear Sir, very truly yours,

M. FARADAY.

The following is a note of Sir H. Davy, alluded to in Mr. Faraday's letter:

TO MR. FARADAY.

SIR, December 24, 1812.

I AM far from displeased with the proof you have given me of your confidence, and which displays great zeal, power of memory, and attention. I am obliged to go out of town, and shall not be settled in town till the end of January: I will then see you at any time you wish.

It would gratify me to be of any service to you. I wish it may be in my power. I am, Sir, your obedient humble servant,

H. DAVY.

I must now recall the reader's attention to the affair of the gunpowder manufactory, to which some allusion has been already made. It is far from my wish to intrude upon the public any account of a private transaction; but the circumstances to which I must refer are already well known, and I believe, moreover, that they have been the subject of misrepresentation.

The letters I shall introduce appear to me highly interesting; and by the warmth of feeling with which they repel the bare suspicion of his prostituting science to the acquisition of wealth, to develope a feature in his character too important to be omitted in a memoir of his life.

From the following letter, it would appear that Davy's alarms, with respect to his responsibilities, were first awakened by a sight of the labels, in which his name was introduced.*

TO JOHN GEORGE CHILDREN, ESQ.

MY DEAR CHILDREN, Rokeby, July — 1813.

I AM very sorry you did not come to Cobham, as the party was very pleasant.

Your apparatus was magnificent, worthy an Imperial Institute: there were some swine however for the pearls; at least, there was one,—you cannot suppose I mean any other than ——

I have been much disturbed and vexed by enquiries respecting the price

* I am here bound to state, from a careful examination of all the original documents, that his name was introduced in the very words which he suggested, and which I have at this moment before me in his own handwriting—so differently, however, does the same sentence strike the eye in print and in manuscript, that an author frequently does not recognise his own composition.

of *my* gunpowder, which from the labels I find is supposed to be *sold* by me. These labels must be altered, so as to put in a clear point my relations to the manufacture; and it must be understood by the public that I have given my gratuitous assistance and advice only.

I have written to Mr. Burton by post, giving two forms. I shall do you more good if these are adopted than I can now; and I wish them to be adopted speedily, as it may otherwise get abroad that I have nothing to do with the powder, and that my name is used in a manner which does not meet my approbation.

In the labels in the windows, it should not be *under my directions,* for this implies that I am a superintendent in the manufactory; but it should be—“ RAMHURST GUNPOWDER, manufactured by Messrs. B. C. and Co. In the composition of this powder, the proprietors have been assisted by the advice and assistance of Sir H. Davy.”

A fair statement will do the manufacture good. Misapprehension will do it much harm.

I am now at Rokeby; we shall be in a few days at Braham Castle, Lord Mackenzie's, near Dingwall, where we shall stay for a week. After that we shall go to the Marquis of Stafford's, Dunrobin, near Goldspie.

I am, my dear Children,

Very truly and affectionately yours,

H. DAVY.

TO THE SAME.

MY DEAR CHILDREN, Edinburgh, July 22.

I WROTE to you from Rokeby. I expressed my feelings respecting the gunpowder. I have been in extreme harrass and anxiety from the idea of the use of my name, without the proper explanation, and I certainly expected that no use would have been made of it without my sanction. I never saw the label for the canister till it came to me upon one of them, and I immediately expressed that I was not satisfied with it.

I told Mr. Burton expressly, that in all cases in which my name was used it must be in my own way. He is now at the head of your firm; but it is to *you,* and not to *him,* that I have given, and shall give my assistance.

Every feeling of friendship and affection prompts my wishes to be useful to you; I have not the same relations to Mr. Burton.

I am very sorry to give you any trouble on this business, but I am sure you cannot wish me to remain in a state of anxiety; and all the friends with whom I have consulted think it absolutely necessary for my reputation, that, when my name is used, a clear statement should be given of the true nature of the connexion.

I think it will be more useful to you, and increase your influence and power in the partnership, if my assistance is stated as given to you, and to you only—in this way: " Ramhurst Gunpowder, manufactured by Messrs. Burton, Children, and Co. after an improved process, founded upon experiments and investigations made by Sir H. Davy, and communicated by him to Mr. J. G. Children, under whose immediate superintendence the gunpowder is made."

I have fully made up my mind on this matter; and if you approve of the above form, I will state it to be the only one to which I will consent.

If the gunpowder is called Sir H. Davy's powder, it must be stated in all cases where my name is used, that it is so called in honour of my discoveries in chemistry, and because I have given my gratuitous assistance in making the experiments and investigations on which the process is founded.

I have resolved to make no profit of any thing connected with science. I devote my life to the public in future, and I must have it clearly understood, that I have no views of profit in any thing I do.

I am, my dear Children,

Very affectionately yours,

H. Davy.

In subsequent letters, which it is not necessary to publish, Davy dwells upon the necessity of his engagements as a partner being legally cancelled, as he cannot endure the idea of his philosophical repose and usefulness being disturbed by the cares of business, or the trouble of litigation.

It is scarcely necessary to add, that all the parties concerned in this transaction most readily and cheerfully met Davy's wishes, all erroneous impressions were effaced, and the affair was adjusted amicably and satisfactorily; and he prepared to quit England with a mind relieved from all the fears and anxieties which had so unfortunately oppressed it.

After the Emperor of the French had sternly refused his passport to several of the most illustrious noblemen of England, it was scarcely to be expected that Sir H. Davy would have been allowed to travel through France, in order to visit the extinct volcanoes in Auvergne, and afterwards to examine that which was in a state of activity at Naples.

No sooner, however, had the discovery of the decomposition of the alkalies and earths, and its probable bearings upon the philosophy of volcanic action, been represented by the Imperial Institute to Napoleon, than, with a liberality worthy of the liberator of Dolomieu, and consistent with his well-known patronage of science, he immediately and unconditionally extended the required indulgence.

In consequence of this permission, Sir Humphry and Lady Davy, the former accompanied by Mr. Faraday as secretary and chemical assistant, and the latter by her own waiting-maid, quitted London on the 13th of October 1813, and proceeded to Plymouth; at which port they immediately embarked in a cartel for Morlaix in Brittany.

On landing in France, they were instantly arrested by the local authorities of the town, who very reasonably questioned the authenticity of their passports, believing it impossible that a party of English should, under any circumstances, have obtained permission to travel over the Continent, at a time when the only English in France were detained as prisoners. They were accordingly compelled to remain during a period of six or seven days at the town of Morlaix, until the necessary instructions could be received from Paris. As soon, however, as a satisfactory answer was returned, they were set at liberty; and they reached the French capital on the evening of the 27th of the same month.

Shortly after his arrival, Davy called upon his old friend and associate Mr. Underwood, who, although one of the *détenus*, had during the whole war enjoyed the indulgence of residing in the capital.

The expected arrival of Davy had been a subject of conversation with the French *savans* for more than a month. Amongst those who were loudest in his praises, was M. Ampère, who had for several years frequently expressed his opinion that Davy was the greatest chemist that had ever appeared. Whether this flattering circumstance had been communicated to the English philosopher I have no means of ascertaining; but Mr. Underwood informs me that the very first wish that Davy expressed was to be introduced to this gentleman, whom he considered as the only chemist in Paris who had duly appreciated the value of his discoveries; an opinion which he afterwards took no care to conceal, and which occasioned amongst the *savans* much surprise, and some dissatisfaction. M. Ampère, at the time of Davy's arrival, was spending the summer at a place a few miles from Paris, in consequence of which the introduction so much desired was necessarily delayed.

On the 30th he was conducted by Mr. Underwood to the Louvre. The English philosopher walked with a rapid step along the gallery, and, to the great astonishment and mortification of his friend and *ciceroni,* did not direct his attention to a single painting; the only exclamation of surprise that escaped him was—"What an extraordinary collection of fine frames!"—On arriving opposite to Raphael's picture of the Transfiguration, Mr. Underwood could no longer suppress his surprise, and in a tone of enthusiasm he directed the attention of the philosopher to that most sublime production of art, and the chef d'œuvre of the collection. Davy's reply was as laconic as it was chilling—"Indeed, I am glad I have seen it;" and then hurried forward, as if he were desirous of escaping from any critical remarks upon its excellencies.

They afterwards descended to a view of the statues in the lower apartments: here Davy displayed the same frigid indifference towards the higher works of art. A spectator of the scene might have well imagined that some mighty spell was in operation, by which the order of nature had been reversed:—while the marble glowed with more than human passion, the living man was colder than stone! The apathy, the total want of feeling he betrayed on having his attention directed to the Apollo Belvidere, the Laocoon, and the Venus de Medicis, was as inexplicable as it was provoking; but an exclamation of the most vivid surprise escaped him at the sight of an Antinous, treated in the Egyptian style, and sculptured in *Alabaster.**—"Gracious powers," said he, "what a beautiful stalactyte!"

What a strange—what a discordant anomaly in the construction of the human mind do these anecdotes unfold! We have here presented to us a philosopher, who, with the glowing fancy of a poet, is insensible to the divine beauties of the sister arts! Let the metaphysician, if he can, unravel the mystery,—the biographer has only to observe that the Muses could never have danced in chorus at his birth.

On the following morning, Mr. Underwood accompanied him to the Jardin des Plantes, and presented him to the venerable Vauquelin, who was the

* The celebrated Italian antiquary Visconti has so denominated it.

first scientific man he had seen in Paris. On their return they inspected the colossal Elephant which was intended to form a part of the fountain then erecting on the site of the Bastile. Davy appeared to be more delighted with this stupendous work than with any object he saw in Paris: to its architect, M. Alavair, he formed an immediate attachment. It has been observed that, during his residence in this city, his likes and dislikes to particular persons were violent, and that they were, apparently, not directed by any principle, but were the effect of sudden impulse.

In the course of removing the foundations, and in digging the canal, the subterranean dungeons of the Bastile were discovered; they were eight in number, and were called *Les Oubliettes.* As they were under the level of the ditch of the fortress, any attempt to escape from them by piercing the wall, must have inevitably drowned the unhappy prisoner together with all those who inhabited the contiguous cells; one of which was discovered with the entrance walled up. Upon demolishing this wall there appeared the skeleton of the last wretched person who had been thus entombed. In all these discoveries Davy took the warmest interest.

Upon the construction of the Elephant, Davy wrote a letter to M. Alavair, to which I am desirous of directing the attention of my scientific readers. It derives its peculiar interest from the opinion which he at that period entertained upon the subject of the excitement of Voltaic action by the contact of different metals.

TO M. ANTOINE ALAVAIR.

SIR, September 23, 1809.

It will give me much pleasure if I can repay your civility to me by offering any hints that may be useful in the execution of the magnificent work constructing under your directions.

Ten parts of copper to one of tin is an excellent composition for a work upon a great scale, nor do I believe any proportions can be better.

There is no fear of any decay in the armatures, if they can be preserved from the contact of moisture; but if exposed to air and moisture, the presence of the bronze will materially assist their decay. Wherever the iron is exposed to air, it should, if possible, be covered with a thin layer of bronze. When the iron touches the foundation of *lead,* it should in like manner be covered either by lead or bronze. A contact between metals has no effect of corrosion, unless a Voltaic circle is formed with moisture, and then the most oxidable metal corrodes; and iron corrodes rapidly both with lead and bronze

The cement which will probably be found the most durable will be lime, fine sand, and scoria of iron. The materials should be very fine and intimately mixed. The ancients always made their cements for great works some months before they were used. I have the honour to be, Sir, with much consideration,

Your obedient humble servant,

H. Davy.

Davy took up his abode at the Hotel des Princes, Rue Richelieu; whither the principal *savans* of Paris hastened to pay their respects; which they did with an alacrity and cheerfulness equalled only by the courtesy of manner with which they expressed their congratulations.

On the 2nd of November, Davy attended the First Class of the Institute, and was placed on the right hand of the President, who on taking the chair announced to the meeting that it was honoured by the presence of "Le Chevalier Davy."

While Davy was at the meeting of the Institute, a curious adventure occurred to Lady Davy, the relation of which may serve to shew the state of surveillance in which the citizens of Paris were held at that period.

Her Ladyship, attended by her maid, had walked into the Thuilleries' Garden. She wore a very small hat, of a simple cockle-shell form, such as was fashionable at that time in London; while the Parisian ladies wore bonnets of most voluminous dimensions. It happened to be a saint's day, on which, the shops being closed, the citizens repaired in crowds to the garden. On seeing the diminutive bonnet of Lady Davy, the Parisians felt little less surprise than did the inhabitants of Brobdignag on beholding the hat of Gulliver; and a crowd of persons soon assembled around the unknown exotic; in consequence of which, one of the inspectors of the garden immediately presented himself, and informed her Ladyship that no cause of '*rassemblement*' could be suffered, and therefore requested her to retire. Some officers of the Imperial Guard, to whom she appealed, replied, that, however much they might regret the circumstance, they were unable to afford her any redress, as the order was peremptory. She then requested that they would conduct her to her carriage; an officer immediately offered his arm, but the crowd had by this time so greatly increased, that it became necessary to send for a corporal's guard; and the party quitted the garden, surrounded by fixed bayonets.

November 3rd, Humboldt and Gay-Lussac paid their first visit of compliment to Davy.

5th.—M. Ampère, who came to Paris expressly for the occasion, was introduced to Davy by Mr. Underwood, and the two philosophers appeared equally delighted with each other. Some years afterwards, however, this feeling of friendly regard, on the part of Davy, was turned into one of bitter aversion, in consequence, as it has been supposed, of certain perfidious insinuations, by which some of the *savans,* instigated by feelings of jealousy, had contrived to prejudice his mind; and which even led him to exert all his efforts to oppose the election of Ampère as a foreign member of the Royal Society.

After Ampère's visit, Mr. Underwood accompanied Sir H. and his lady to the Imperial Library in the Rue Richelieu, and afterwards to the cathedral of Notre Dame, where they inspected the crown and imperial regalia. The splendour of the coronation mantle of Napoleon may be imagined, when it is stated that its weight exceeded eighty pounds, and that it was lined with the skins of six thousand ermines.

6th.—They visited the Museum of French Monuments, in the Rue des Petits Augustines, which contained the tombs and sculptured ornaments preserved from the churches that were demolished during the Revolution. This interesting collection, shortly after the restoration of the Bourbons, was dispersed. It is a singular fact, that Davy expressed more admiration at this inferior exhibition of art, than he did at that of the Greek and Roman statues in the Museum of the Louvre. Whether his taste had been vitiated by the inspection of less perfect models in his earlier days, is a question which I shall leave more competent judges to decide.

10th..—They dined with Count Rumford at Auteuil, who shewed his laboratory to Davy: this was exactly eight months before the poor broken-hearted Count sank into the grave, the victim of domestic torment, and of the persecutions of the French *savans,* instigated by his wife, the widow of the celebrated Lavoisier.

13th.—The anniversary dinner of the Philomatic Society took place on this day, at a restaurateur's in the Rue St. Honoré; M. Dumeril in the chair. Although it was very unusual to invite any stranger upon this occasion, Sir H. Davy and his English friend were requested to favour the company by their presence. Thirty-three members were in attendance, amongst whom were Ampère, Brogniart, Cuvier, Chevreuil, Dulong, Gay-Lussac, Humboldt, Thénard, &c.

At this dinner various complimentary toasts were proposed: and first, the Royal Society of London, for which Davy having returned thanks, gave the Imperial Institute. The Linnæan Society of London, and the Royal Society of Berlin, were given in succession. But the circumstance which evinced the greatest feeling and delicacy towards their English guest, was the company's declining to drink the health of the Emperor. It placed their personal safety even in some jeopardy; and not a little apprehension was afterwards felt as to how far Napoleon might resent such a mark of disrespect, for seven-eighths of the members present were placemen.

November 17th.—Mr. Underwood states that on this day he met Humboldt at dinner at Davy's hotel; and he adds—"I do not know whether you are aware that Sir Humphry had a superstitious dislike at seeing a knife and fork placed crosswise on a plate at dinner, or upon any other occasion; but I can assure you that such was the fact; and when it occurred in the company of his intimate friends, he always requested that they might be displaced; whenever this could not be done, he was evidently very uncomfortable."

At about this period, but I am unable to ascertain the particular day, the junior chemists, with Thénard as their leader, gave Davy a sumptuous dinner at one of the most celebrated restaurateurs in Paris. The following persons formed a committee for that purpose: Gay-Lussac, Thénard, Dulong, Chevreuil, Laugier, Robiquet, and Clement. As it was by the chemists only that this dinner was given, neither Arago nor Ampère was included; but Berthollet, Chaptal, and Vauquelin were invited.

On the morning of the 23rd of November,* M. Ampère called upon Davy, and placed in his hands a small portion of a substance which he had received from M. Clement; and, although it had been in the possession of the French chemists for more than twelve months, so entirely ignorant were they of its true nature and composition, that it was constantly spoken of amongst themselves as X, the *unknown* body.

How far the suggestions of Davy led to the discovery of the chemical nature of this interesting substance, which has been since distinguished by the name of *Iodine*, is a question which has given rise to much discussion on the

* The date of this event is important; and Mr. Faraday, in referring to his Journal, finds it to be correctly stated.

Continent. It has been moreover questioned, how far the love of science, and the fervour of emulation, can justify the interference which Davy is said to have displayed upon the occasion. He is accused of having unfairly taken the subject out of the hands of those who were engaged in its investigation, and to have anticipated their results.

As his biographer, I feel that it is not only due to the character of Davy, but essential to the history of Science, that these questions should be impartially examined; and I have spared no pains in collecting facts for their elucidation. Mr. Underwood, who was in the constant habit of associating with the parties concerned in the enquiry, has furnished me with some important particulars, and his testimony is fortified by published documents.

The substance under dispute was accidentally discovered by M. Courtois, a manufacturer of saltpetre at Paris, but kept secret by him for several years; at length, however, he communicated it to M. Clement, who made several experiments on it, but without any favourable result. On the 23rd of August 1813, Clement exhibited to Mr. Underwood the beautiful experiment of raising it into a violet-coloured vapour, and that gentleman assures me that this was the only peculiar property which had at that time been recognised as distinguishing it. A few days previous to this event, M. Ampère had received a specimen of the substance, which he had carefully folded up in paper, and deposited in his pocket, but on arriving at home, and opening the packet, he was surprised to find that his treasure had vanished. Clement, however, furnished him with another supply, and it was this parcel that Ampère transferred into the hands of Davy; and "for which," says Mr. Underwood, "he told me a few days ago, that Thénard and Gay-Lussac were extremely angry with him."

The first opinion which the French chemists entertained respecting the nature of Iodine, was that it was either a compound of muriatic acid, or of chlorine, since it formed with silver what appeared to be a muriate, or a chloride of that metal; but Davy at once observed that the substance so produced blackened too quickly in the sun to justify that opinion. He, however, determined to submit it to a more rigorous examination; and during the latter part of November he worked upon it at his hotel with his own apparatus, and on the 3rd of December in the laboratory of Mr. Chevreul, at the Jardin des Plantes, with whom, it may be stated in passing, he perhaps formed a stricter intimacy than with any other chemist during his sojourn in Paris.

Chevreul, however, be it known, was a brother of the angle; and I understand that he still preserves, as sacred trophies, some artificial flies with which Davy had supplied him.

Having pointed out the channel through which Iodine first fell into the hands of Davy, let us pursue its history. The first public notice of its existence was read by Clement at the Institute, on the 29th of November 1813. At the meeting of the 6th of December, Gay-Lussac, who had only received some X a few days previous to this date, presented a short note, in which he gave the name of *Iode* to the body, and threw out a hint as to its great analogy to chlorine, while he stated that two hypotheses might be formed as to its nature, that it might be considered as a simple substance, or as a compound of oxygen. On the 13th of the same month, a letter addressed to M. le Chevalier Cuvier, and dated December 11th, was read from Davy to the Institute, in which he offered a general view of its chemical nature and relations;* and on the 20th of January 1814, he communicated to the Royal Society of London, a long and elaborate paper, dated Paris, December 10, 1813, and entitled, "Some Experiments and Observations on a new Substance, which becomes a violet-coloured gas by Heat." In this paper, while the author assigned to Gay-Lussac all the credit to which his communication of the 6th of December may be supposed to entitle him, he evidently felt that some explanation was due to the chemical world for his having pursued the enquiry. "M. Gay-Lussac," he observes, "is still engaged in experiments on this subject, and from his activity and great sagacity, a complete chemical history of it may be anticipated. But as the mode of procuring the substance is now known to the chemical world in general, and as the combinations and agencies of it offer an extensive field for enquiry, and will probably occupy the attention of many persons; and as the investigation of it is not pursued by the discoverer himself, nor particularly by the gentlemen to whom it was first communicated, I shall not hesitate to lay before the Royal Society an account of the investigations I have made upon it; and I do this with the less scruple, as my particular manner of viewing the phenomena has led me to some new results, which probably will not be considered by the Society as without interest in their relation to the general theory of chemistry, and in their possible application to some of the useful arts."

* See *Annales de Chimie*, tome 88, p. 322. It appears from Mr. Faraday's Journal, that he worked upon Iodine with a borrowed Voltaic pile, at his hotel, on the morning of the 11th; and the results of his experiments are described at the conclusion of the above letter.

It was not until August 1814, that Gay-Lussac read his paper on the subject, which was subsequently published in the *Annales de Chimie.*

After the above short, but I trust honest statement, can any reasonable doubt exist, that, if Davy had not visited Paris, Iodine would have remained at the end of the year 1814, as it had been for two preceding years—the unknown X?

In a communication published in the first volume of the Royal Institution Journal, Davy offers the following observations upon this subject: "With regard to Iodine, the first I had of it was from M. Ampère, who, before I had seen the substance, supposed that it might contain a new supporter of combustion.

"Who had most share in developing the chemical history of that body, must be determined by a review of the papers that have been published upon it, and by an examination of their respective dates. When M. Clement shewed Iodine to me, he believed that the hydriodic acid was muriatic acid; and M. Gay-Lussac, after his early experiments, made originally with M. Clement, formed the same opinion, and *maintained* it, when I *first* stated to him my belief that it was a new and peculiar acid, and that Iodine was a substance analogous in its chemical relations to Chlorine."

I was very desirous of ascertaining the feeling which at present prevails amongst the French chemists upon this subject; and I therefore requested Mr. Underwood to make such enquiries as might elicit the required information. In a letter from that gentleman, dated "Paris, August 22, 1830," he says, "Though Thénard and Gay-Lussac retain great bitterness of feeling towards Davy, on account of the affair of Iodine, Chevreul and Ampère are still, as they ever were, of opinion, that such a feeling has its origin in a misconception; that what Davy did, was from the honest desire of promoting science, and not from any wish to detract from the merit of the French chemists."

During his visit to Paris, Davy was not introduced to the Emperor. Lady Davy observed to me, that, although Sir Humphry felt justly grateful for the indulgence granted to him as a Philosopher, he never, for a moment, forgot the duty he owed his country as a Patriot; and that he objected to attend the levee of her bitterest enemy. On the other hand, it is said that Napoleon never expressed any wish to receive the English chemist; and those who seek in the depths for that which floats upon the surface, have racked their imaginations in order to discover the source of this mysterious indifference; but I apprehend that we have only to revert to the political state of Europe in the year 1813, and the problem will be solved.

Amongst the reasons for supposing that the Emperor must have felt ill disposed towards the English philosopher, the following story has been told; which, as an anecdote, is sufficiently amusing; and I can state upon the highest authority, that it is moreover perfectly true.

It is well known that Bonaparte, during his whole career, was in the habit of personal intercourse with the *savans* of Paris, and that he not unfrequently attended the sittings of the Institute. Upon being informed of the decomposition of the alkalies, he asked, with some impetuosity, how it happened that the discovery had not been made in France?—"We have never constructed a Voltaic battery of sufficient power," was the answer. "Then," exclaimed Bonaparte, "let one be instantly formed, without any regard to cost or labour."

The command of the Emperor was of course obeyed; and, on being informed that it was in full action, he repaired to the laboratory to witness its powers; on his alluding to the taste produced by the contact of two metals, with that rapidity which characterised all his motions, and before the attendants could interpose any precaution, he thrust the extreme wires of the battery under his tongue, and received a shock which nearly deprived him of sensation. After recovering from its effects, he quitted the laboratory without making any remark, and was never afterwards heard to refer to the subject.

It is only an act of justice to state that Davy, during his residence in the French capital, so far from truckling to French politics, never lost an opportunity of vindicating with temper the cause of his own country. At the Théâtre de la Porte Saint Martin, a melodrame was got up, with the avowed intention of exposing the English character to the execration of the audience. Lord Cornwallis was represented as the merciless assassin of the children of Tippo Saib. Davy was highly incensed at the injustice of the representation, and abruptly quitted the theatre in a state of great indignation.

Whatever objections might have existed in his mind, as to his attending a levee of the Emperor, they did not operate in preventing his being presented to the Empress at Malmaison; but he could not be prevailed upon to appear upon that occasion, in any other than a morning dress; and it was not until after repeated entreaty, and the assurance that he would not be admitted into the *Salle de reception*, that he consented to exchange a pair of half-boots that laced in front, and came over the lower part of his pantaloons, for black silk stockings and shoes. His constant answer to the remonstrances of his friends was, "I shall go in the same dress to Malmaison as that in which I called upon the Prince Regent at Carlton House."

The introduction of Sir Humphry and Lady Davy to the Empress Josephine, took place at Malmaison on the 30th of November. The only English present were, the Earl of Beverley, a *détenue;* General Sir Edward Paget, a prisoner of war, taken in Spain, and Mr. Underwood; and it was the first levee at which any of our countrymen had been introduced, with the exception of Mr. Underwood, who had been frequently in the habit of paying his court to the Empress, and to whom, indeed, he was indebted for those indulgences which have been already mentioned.

The persons present having arranged themselves in a semicircle, the Empress entered the *Salle de reception,* and in her usual gracious manner addressed each individual. After this court ceremony, her Majesty retired, having previously signified to a select few, her desire that they should follow her into the private apartment.

In the Boudoir, the conversation became general, and turned upon certain works of art; and upon Lady Davy expressing, in very florid terms, her admiration of some beautifully embellished cups of Porcelain, which were stationed on the mantel-piece, her Majesty, with that good-nature which ever distinguished her, immediately presented her with a specimen.

The Empress then proposed that Lady Davy should on this occasion visit her conservatories, upon which it is well known she had lavished large sums, and was ambitious to be thought to possess all that was rare and curious. Lady Davy having expressed some apprehensions as to the coldness of the day, and appearing to be but thinly clad, one of the Dames du Palais was commanded to provide cloaks; and in a short time, Mr. Underwood says, a *mountain* of the most costly and magnificent furs, that probably ever appeared even in a Regal Palace, were displayed before her; the splendid trophies, we may conclude, of the Royal conciliation at Tilsit.

It was on the 13th of December 1813, that Davy was elected a corresponding member of the First Class of the Imperial Institute; there were forty-eight members present, and he had forty-seven votes: Guyton de Morveau being the only person who opposed his election.

Nothing ever exceeded the liberality and unaffected kindness and attention with which the *savans* of France had received and caressed the English philosopher. Their conduct was the triumph of Science over national animosity,— a homage to genius, alike honourable to those who bestowed, and to him who received it; and it would be an act of ingratitude, a violation of historical justice, on the part of the English biographer, did he omit to express the pride and admiration with which every philosopher in his country continues to regard it. It would have been fortunate for the cause of Science, and fortunate for the historian, could he have terminated the subject with these remarks; but the biographer has an act of justice to perform, which he must not suffer his friendship to evade, nor his partialities to compromise.

It would be an act of literary dishonesty to assert that Sir H. Davy returned the kindness of the *savans* of France, in a manner which the friends of Science could have expected and desired. There was a flippancy in his manner, a superciliousness and hauteur in his deportment, which surprised as much as they offended. Whatever opinions he might have formed as to the talents of the leading chemists, it was weakness to betray, and arrogance to avow, them.

He had, by a single blow, fatally mutilated the system which was the pride and glory of their nation: it was ungenerous to remind them of his triumph. It required but little tact to have reconciled the French philosophers to the revolution he had effected; but, unfortunately, it cannot be said of Davy, what was so wittily observed of Voltaire,—that if he trod upon the toes of their prejudices, he touched his hat at the same time: even the affair of Iodine, had it been skilfully managed, would never have left an angry feeling. It was not his success, but the manner in which he spoke of it, that rendered it so offensive. He should have acted according to the judicious advice given to a member of the clerical profession, upon his consulting a friend as to the propriety of continuing his field-sports, should he become a dignitary of the Church—"You may hunt, but you must not holla."

It may be supposed that the unguarded conduct of Davy reached the ear of the Emperor; for in a conversation with one of the leading members of the Institute, Napoleon took occasion to observe, that he understood the young English chemist held them all in low estimation.

Having thus candidly avowed the errors of Davy, I may be justified in claiming from the reader his confidence in the sincerity with which I shall attempt to palliate them. From my personal knowledge of his character, I am inclined to refer much of that unfortunate manner, which has been considered as the expression of a haughty consciousness of superiority, to the desire of concealing a *mauvaise honte* and *gaucherie*—an ungraceful timidity, which he could never conquer. The bashful man, if he possess strong passions, will frequently force himself into a state of effrontery, by a violence of effort which passes amongst ordinary observers for the sallies of pride, or the ebullitions of temper; whereas if, on the contrary, his temperament be cold and passionless, he will exhibit traits of the most painful reserve. This proposition cannot, perhaps, be more forcibly illustrated than by a comparison of the manners of Davy and Cavendish, whose temperaments were certainly as much opposed to each other as fire is to ice: the latter, however, was shy and bashful, to a degree bordering upon disease; and nothing so much distressed him as an introduction to strangers, or as his being pointed out as a person distinguished in science. On one of the Sunday evening *soirées* of Sir Joseph Banks, he happened to be conversing with his friend Mr. Hatchett, when Dr. Ingenhouz, who was rather remarkable for pomposity of manner, approached him with an Austrian gentleman in his hand, and introduced him formally to Mr. Cavendish. He recounted the titles and qualifications of his foreign friend at great length, and concluded by saying, that he had been particularly anxious to be introduced to a philosopher so universally celebrated throughout Europe as Mr. Cavendish. As soon as Dr. Ingenhouz had finished, the Austrian gentleman began; he assured Mr. Cavendish that one of his principal inducements in coming to London, was to see and converse with one whom he considered the most distinguished chemist of the age. To all these high-flown addresses, Mr. Cavendish answered not a single word, but stood with his eyes cast down upon the floor, in a state of the most painful confusion. At length, espying an opening in the crowd, he darted through it with all the speed he could command, and never stopped until he reached his carriage, which immediately drove him home.

From the same cause, probably, arose Davy's inattention and carelessness in those little observances of etiquette, which many may treat as empty and unmeaning ceremonials, but which the members of a polished community regard as the delicate expressions of feeling, and the language of sentiment.

It is said that, on conversing in the chamber of the Institute, he received one of its most distinguished and venerable members, who approached him with the air of salutation, without rising from his seat; a circumstance perhaps in itself of very trifling importance, but it was considered as a mark of disrespect, which is not readily forgiven, when a spirit of rivalry may be supposed to sharpen the affront. It will be remembered that Cæsar might date his loss of popularity to the fact of his having received the Senate while sitting in the porch of the temple of Venus, and that it formed one of the chief pretences of those who organised the conspiracy against his person.

There were, besides, other sources of unpopularity, which we are bound in fairness and candour to impute to the excellencies, rather than to the defects, of his character. If we believe with Johnson, that men have sometimes gained reputation from their foibles, we may certainly admit the converse of the proposition, that they have occasionally lost it from their virtues. Davy, as we have seen, possessed from his earliest years a frankness of disposition which endeared him to all his friends, but in after life it unquestionably exposed him to various annoyances, which by a little reserve he would have certainly escaped. It is quite surprising how much a little mystery, judiciously managed, will achieve. Seven veils converted the fragment of a tile, ploughed up in the neighbourhood of Florence, into an object of awful devotion.*

Although it must be admitted that our philosopher lost some popularity during his visit to the French metropolis, the *savans* did not the less respect his talents, or admire his discoveries. They appear to have been impressed with the same sentiment as that which animated Voltaire, when he asked whether the discovery of Racine's weakness made the part of Phædra less admirable.

M. Dumas, who is certainly by no means distinguished for the readiness with which he is disposed to pay homage to British talent, has declared that Davy was the greatest chemical genius that ever appeared.

In fact, the more the researches of this great experimentalist are studied, the more they must be admired: every attempt to depreciate their intrinsic importance will only serve to display their exalted merits; every attempt to falsify their results will only tend to demonstrate their accuracy. It is by an elaborate examination only, that the full evidence of their truth can be displayed; there are points which the keen eye of genius will discern, that are invisible to a grosser sense: the coldness of criticism then will only make them glow the brighter; like his own potassium, the contact even of ice, so far from extinguishing, will light them up in splendour.

Sir Humphry left Paris on the morning of the 29th of December, and proceeded by the way of Lyons to Montpellier, where he remained for a month, and became acquainted with M. Berard, who afterwards filled the chemical chair in that university, and in whose laboratory he worked upon the subject

* Gray's Letters.

of Iodine, and examined many of the marine productions of the Mediterranean, with the view of determining whether they contained that body. M. Berard directed a considerable quantity of the species of *Ulva*, which abounds on the coast of Languedoc, to be burnt for him; and although the ashes consisted for the most part of common salt, he obtained traces of Iodine in the lixivium. From the general results of his experiments, however, he concludes, that the ashes of the *fuci* and *ulvæ* of the Mediterranean afford it in much smaller quantities than the sea-weed, from which soda is procured; and it was only in a very few instances that he could derive any evidence of its existence. In the ashes of the corallines and sponges,* he could not obtain the slightest indication of its presence. During this period he also extended his enquiries respecting the chemical agencies of Iodine, and the properties of several of its compounds, especially of those in which he believed it to exist in triple combination with alkalies and oxygen, and for which he proposed the name of *Oxy-iodes*.†

While at Montpellier, Davy witnessed the procession of the Pope on his return to Rome. His Holiness appeared in a state of great humiliation, and, on being supplicated by a poor woman to cure her child, he replied, that she must propitiate Heaven by her prayers, for that he was himself a mere mortal, without power to heal or to save.

He quitted Montpellier on the 7th of February, and, accompanied by M. Berard, visited the fountain of Vaucluse; he afterwards continued his route to Nice, crossed the Col de Tende, to Turin, and arrived at Genoa on the 25th of February; from which place the following letter is dated.

TO MR. UNDERWOOD.

MY DEAR UNDERWOOD, Genoa, March 4.

I HAVE not received the letter you announced to me in the street, concerning Ampère's note, nor any others since I left Paris. The note came to me through the Prefect of Nice, with an indorsement by M. Degerand.

I crossed the Alps by the Col de Tende, stayed at Turin three days, and came here through snow and ice, over the Bochetta, where I have been waiting

* So much for the opinion of those medical authors who refer the efficacy of burnt sponge to Iodine.

† These are the *Iodates* of the present day; but Davy, it would seem, resisted the conviction of Iodic acid being an *oxy-acid*, upon the same grounds that he opposed the views of M. Gay-Lussac with regard to the nature of Chloric acid.

for a fair wind for Tuscany. We have had no impediments except from the snow and the east winds.

If you can hear any thing of the destination of the letters I have twice missed, I shall thank you to let me know by addressing me at Rome at the *Posta.* I shall be most happy to hear some news of you here, and shall always feel a lively interest in your plans, and in your welfare.

I have been making some experiments here on the Torpedo, but without any decisive results; the coldness of the weather renders the powers of the animal feeble; I hope, however, to resume them at Naples.

Tell M. Ampère, I hope he will not give up the subject of the laws of the combination of gaseous bodies, which is so worthy of being illustrated by his talents, and which offers such ample scope for his mathematical powers, united as they are with chemical knowledge:—tell him also that I hope he will sometimes write to me, and that I shall always remember with pleasure the hours I have passed in his society.

Pray tell me that you are well; and remember me to all that are interested in me. My wife desires her kind remembrances.

I am, my dear Underwood,

Your very sincere friend,

H. Davy.

Besides researches on the torpedo, Davy made farther experiments on the ashes of sea-weed, which were collected for him by Professor Viviani, of Genoa.

He left Genoa by water on the 13th, and arrived at Florence on the 16th of March. Here he worked in the laboratory of the Academia del Cimento, on Iodine; but more particularly on the combustion of the Diamond. The experiments on this latter body were performed by means of the great lens in the cabinet of Natural History; the same instrument as that employed in the first trials on the action of the solar heat on the diamond, instituted by Cosmo III. Grand Duke of Tuscany: upon this occasion, he was assisted by Count Bardi, the Director, and Signior Gazzari, the Professor of Chemistry at the Florentine Museum.

I have been informed that the hasty, and apparently careless manner in which he conducted his experiments, and which has been already noticed* as

* Page 96.

being characteristic of his style of manipulation, greatly astonished the philosophers of Florence, and even excited their alarm for the safety of the lens, which on all occasions had been used by them with such fastidious caution and delicacy.

In the very first trials on the combustion of the diamond, he ascertained a very curious circumstance that had not been before noticed; namely, that the diamond, when strongly ignited by the lens in a thin capsule of platinum, perforated with many orifices, so as to admit a free circulation of air, will continue to burn in oxygen gas after being withdrawn from the focus. The knowledge of this circumstance enabled him to adopt a very simple apparatus, and mode of operation in his researches, and to complete in a few minutes experiments which had been supposed to require the presence of a bright sunshine for many hours.

The new facts obtained by the experiments on Iodine, which he had commenced at Montpellier and carried on at Florence, he embodied in a memoir, which was read before the Royal Society on the 16th of June 1814. It treated more particularly of the triple compounds containing iodine and oxygen,—of the hydrionic acid, and of the compounds procured by means of it,—of the combinations of iodine and chlorine,—of the action of some compound gases on Iodine,*—and, lastly, of the mode of detecting Iodine in combinations. "If Iodine," he says, "exists in sea water, which there is every reason to believe must be the case, though in extremely minute quantities, it is probably in triple union with oxygen and sodium, and in this case it must separate with the first crystals of common salt."

He quitted Florence on the 3rd, and having visited Sienna, entered Rome on the 6th of April. The Continent having now become accessible, he met with many of his English friends; but neither the extended society by which he was surrounded, nor the classical attractions of the city of the Cæsars, allured him from the pursuits of Science. We find that, shortly after his arrival, he renewed his researches on the combustion of different kinds of charcoal, in the laboratory of the Academia del Lyncei, in which he was assisted by Sig. Morrichini and Barlocci, Professors of the College Sapienza at Rome. Having arranged the results of this investigation, together with those relating to the combustion of the diamond, which he had previously obtained at Flo-

* The compounds which he supposed to be thus produced are of a very questionable nature; with respect to that formed with the Olefiant gas, he was evidently in error.

rence, he transmitted a paper to the Royal Society, entitled "Some Experiments on the Combustion of the Diamond, and other carbonaceous substances;" which was read on the 23rd of June, and published in the Second Part of the Philosophical Transactions for the year 1814.

No sooner had it been established by various accurate experiments, that the diamond and common charcoal consumed nearly the same quantity of oxygen in combustion, and produced a gas having the same obvious qualities, than various conjectures were formed to explain the remarkable differences in the sensible qualities of these bodies, by supposing some minute difference in their chemical composition. MM. Biot and Arrago, from the high refractive power of the diamond, suspected that it might contain hydrogen. Guyton Morveau inferred from his experiments that it was pure carbon, and that charcoal was an oxide of carbon; whereas Davy was inclined to believe, from the circumstance of the non-conducting power of the diamond, as well as from the action of potassium upon it, that a minute portion of oxygen might enter its composition, although such a supposition would be at variance with the doctrine of definite proportions; but more lately, in his account of some new experiments on the fluoric compounds, he hazarded the idea that it might be the carbonaceous principle combined with some new and subtile element, belonging to the same class as oxygen, chlorine, and fluorine, which has hitherto escaped detection, but which may be expelled, or newly combined, during its combustion in oxygen. "That some chemical difference," says Davy, "must exist between the hardest and most beautiful of the gems and charcoal, between a non-conductor and a conductor of electricity, it is scarcely possible, notwithstanding the elaborate experiments that have been made on the subject, to doubt: and it seems reasonable to expect, that a very refined or perfect chemistry will confirm the analogies of Nature, and show that bodies cannot be exactly the same in composition or chemical nature, and yet totally different in all their physical properties."

With these impressions, we may readily imagine the ardour with which Davy availed himself of the use of the great lens at Florence. He had in various ways frequently attempted to fuse charcoal,* but without success. In a letter addressed to Mr. Children is the following passage: "The great re-

* The supposed fusion of charcoal by Professor Silliman, by means of Dr. Hare's galvanic deflagrator, was a fallacy arising from the earthy impurities of the substance. See *American Journal of Science*, vol. v. p. 108, and 361.

sult to be hoped for is the fusion of carbon; and then you may use diamond in the manufacture of gunpowder."

He tells us that he had long felt a desire to make some new experiments on the combustion of the diamond and other carbonaceous substances; and that this desire was increased by the new fact ascertained with respect to iodine, which by uniting to hydrogen, affords an acid so analogous to muriatic acid, that it was for some time confounded with that body. His object in these new experiments, was to examine minutely whether any peculiar matter was separated from the diamond during its combustion, and to determine whether the gas, formed in this process, was precisely the same in its minute chemical nature, as that formed in the combustion of common charcoal. By his experiments at Florence, he satisfactorily accomplished his wishes, and established beyond a question the important fact, that "the diamond affords no other substance by its combustion than pure carbonic acid gas; and that the process is merely a solution of diamond in oxygen, without any change in the volume of the gas."

As one of the principal objects in these researches was to ascertain whether water was formed during the combustion of the diamond, with a view to decide the question of the presence of hydrogen, every possible source of fallacy was excluded. In one experiment there was an evident deposition of moisture, but it was immediately discovered to have been owing to the production of vapour from a cork connected with a part of the apparatus, during the combustion.

In the progress of this research, he ascertained a fact, the knowledge of which must not only be considered as important to the present enquiry, but as highly valuable in excluding error from our reasonings upon the delicate results of analysis* — I allude to the extremely minute quantity of water which becomes perceptible by deposition on a polished glass surface. He introduced a piece of paper weighing a grain into a tube of about the capacity of four cubical inches, the exterior of which was gently heated by a candle; immediately a slight but perceptible dew appeared in the interior of the upper part of the tube; the paper taken out and directly weighed in a balance, sensible to 1-100th of a grain, had not suffered any appreciable diminution. If

* It has a more especial bearing upon that experimental research by which the nature of chlorine was established, as described at page 213, to which I beg to refer the chemical reader.

then on burning 1·84 grains of diamond in oxygen gas, not even a barely perceptible dew was produced, we may consider it as fully proved that this gem cannot contain hydrogen in its composition: but to render the demonstration, if possible, still more complete, he kept a small diamond, weighing ·45 of a grain, in a state of intense ignition by the great lens of the Florentine Museum, for more than half an hour, in chlorine; but the gas suffered no change, and the diamond underwent no alteration either in weight or appearance; now had the smallest portion of hydrogen been developed, white fumes of muriatic acid would have been visible, and a certain condensation of the gas must have taken place.

The general tenor of his results was equally opposed to the idea of the diamond containing oxygen; for, in such a case, the quantity of carbonic acid generated by the combustion, would, on comparison, have indicated that fact. By combining the carbonic acid with lime, and then recovering the gas from the precipitate by muriatic acid, he found its proportion to be exactly that which was furnished by an equal weight of Carrara marble similarly treated.

The enquiry next proceeds to the examination of other forms of carbonaceous matter, such as plumbago, charcoal formed by the action of sulphuric acid on oil of turpentine, and that produced during the formation of sulphuric ether; and lastly, the common charcoal of oak.

In all these bodies, he detected the presence of hydrogen, both by the water generated during their combustion, and by the production of muriatic acid, when ignited in chlorine. The chemical difference then between the diamond and the purest charcoal, would appear to consist in the latter containing hydrogen; but Davy very justly asks whether a quantity of an element, less in some cases than 1-5000th part of the weight of the substance, can occasion so great a difference in physical and chemical characters? "It is certainly possible," says he, "yet it is contrary to analogy, and I am more inclined to adopt the opinion of Mr. Tennant, that the difference depends upon crystallization." In support of such an opinion, he farther adduces the fact, that charcoal after being intensely ignited in chlorine, is not altered in its conducting power or colour: in which case the carbon is freed from the hydrogen, and yet undergoes no alteration in its physical properties.

One distinction supposed to exist between the diamond and common carbonaceous substance, the researches of Davy have certainly removed, viz. its relative inflammability; for he has shown that the former will burn in oxygen with as much facility as plumbago.

The experiments, then, which Davy conducted at Florence and Rome, have removed several important errors with regard to the nature of carbonaceous substances; and though they may not encourage the labours of those speculative chemists who still hope to exemplify the old proverb,* by manufacturing diamonds out of charcoal, they certainly show that they are less chimerical than those of the wild visionaries who sought to convert the baser metals into gold.

While at Rome, Davy was engaged for several successive days in the house of Morrichini, for the purpose of repeating with that philosopher his curious experiments on *magnetisation*. Mr. Faraday was charged with the performance of the experiments, but never could obtain any results.

On the 8th of May he entered Naples, and remained there for three weeks, during which period he visited Mount Vesuvius, and the volcanic country surrounding it. He describes the crater, at this time, as presenting the appearance of an immense funnel, closed at the bottom, with many small apertures emitting steam; while on the side towards Torre del Greco, there was a large aperture from which flame issued to a height of at least sixty yards, producing a most violent hissing noise. He was unable to approach sufficiently near the flame to ascertain the results of the combustion; but a considerable quantity of steam ascended from it; and he says, that when the wind blew the vapours upon him, there was a distinct smell both of sulphurous and muriatic acids, but there was no indication of carbonaceous matter from the colour of the smoke; nor was any deposited upon the yellow and white saline matter which surrounded the crater, and which he found to be principally sulphate and muriate of soda, and in some specimens there was also a considerable quantity of muriate of iron. At this period, when the volcano was comparatively tranquil, he observed the solfaterra to be in a very active state, throwing up large quantities of steam, and some sulphuretted hydrogen.

At several subsequent periods he revisited Vesuvius; and I shall hereafter take occasion to relate all the principal observations he made, and the conclusions at which he arrived, with respect to this the most interesting of all the phenomena of mineral nature.

He also took great interest in the excavations at that time going on at

* "Carbonem pro Thesauro."

Pompeii, under the direction of Murat, then King of Naples, who placed at his disposal several specimens of art, which Davy received with a view to investigate the chemical composition of the colours used by the Ancients.

On the 25th of May he returned to Rome, and again quitted it on the 2nd of June.

I regret to say that the information I have received, as to the future continental travels of our philosopher, is extremely meagre, and will consist of little more than names and dates. Of this, however, the reader may be assured, that nothing which relates to his scientific researches has been omitted.

From Rome he proceeded to Terni, and thence to Bologna, where he remained for three days; then to Mantua, Verona, and Milan. Whether at this or at some subsequent period he went to Pavia, in order to pay his homage to the illustrious Volta, I entertain some doubt; but the time is immaterial to the point of the anecdote I am about to relate.

Davy had sent a letter to Pavia to announce his intended visit; and on the appointed day and hour, Volta, in full dress, anxiously awaited his arrival. On the entrance of the great English philosopher into the apartment, not only in *déshabille*, but in a dress of which an English artisan would have been ashamed, Volta started back in astonishment, and such was the effect of his surprise, that he was for some time unable to address him.

From Milan, which he left on the 22nd of June, he went to Como, Domo D'Ossola, and then over the Simplon, to Geneva, where he arrived on the 25th of that month, and remained until the 18th of September. During this visit he made various experiments on Iodine, at the house of De Saussure, which was situated near the edge of the Lake, and about three miles from Geneva. He also worked at M. Pictet's house, on the subject of the heat in the solar spectrum. Here also he met with a number of celebrated persons, whose society he greatly enjoyed; amongst whom were Madame de Stael, Benjamin Constant, Necker, and Talma. Lausanne, Vevay, Payerne, Berne, Zurich, Schaffhausen, and Munich, were successively visited by him. His route was then continued through Tyrol, Inspruck, Calmar, Bolsenna, Trent, Bassano, Vicenza, Padua, to Venice; where having remained two days, he returned to Padua on the 16th of October, and then proceeded to Ferrara, Bologna, and Pietra-Mala; near which latter place, in the Apennines, he examined a fire produced by gaseous matter constantly disengaged from a schist stratum, and from the results of its combustion, he concluded it to be pure fire-damp. On again reaching Florence, he found that the Professors had been dismissed, but he nevertheless resumed his researches, first at home, and afterwards in the laboratory of the Grand Duke, where he submitted to analysis some gas which had been collected by his attendant Mr. Faraday, from a cavity in the earth, about a mile from Pietra-Mala, then filled with water, and which from the quantity of gas disengaged is called *Aqua Buja.* It was found to be pure light carburetted hydrogen, requiring two volumes of oxygen for its combustion, and producing a volume of carbonic acid gas. " It is very probable," says he, " that these gases were disengaged from coal strata beneath the surface, or from bituminous schist above coal; and at some future period new sources of wealth may be opened to Tuscany from this invaluable mineral treasure."

On the 29th he left Florence, and passing through Levano, Tortona, and Terni, arrived again at Rome on the 2nd of November, where he remained till the 1st of March 1815.

During this winter he was engaged in an elaborate enquiry into the composition of ancient colours; and also in experiments upon certain compounds of iodine and of chlorine. Upon which subjects he transmitted to the Royal Society three memoirs, viz. one entitled, " Some Experiments and Observations on the Colours used in Painting by the Ancients," which was read on the 23rd of February; a second, " On a solid compound of Iodine and Oxygen," read April 10; and a third, " On the action of Acids on the Salts usually called Hyper-oxymuriates, and on the Gases produced from them," read May 4, 1815; all of which were published in the Philosophical Transactions for that year.

Although the paintings of the great masters of Greece have been entirely destroyed, either by accident, by time, or by the barbarian conquerors at the period of the decline and fall of the Roman Empire, yet there is sufficient proof that this art attained a very high degree of excellence amongst a people to whom genius and taste were a kind of birthright, and who possessed a perception, which seemed almost instinctive, of the dignified, the beautiful, and the sublime.

Our philosopher observes, that the subjects of many of those pictures are described in ancient authors, and that some idea of the manner and style of the Greek artists may be gained from the designs on the vases improperly called " Etruscan," which were executed by artists of Magna Græcia, and many of which are probably copies from celebrated works: of their execution and colouring, some faint notion may be gained from the paintings in fresco found at Rome, Herculaneum, and Pompeii; for, although these paintings are not properly Grecian, yet at the period when Rome was the metropolis of the world, the fine arts were cultivated in that city exclusively by Greek artists, or by artists of the Greek school; while it is evident, on comparing the descriptions of Vitruvius and Pliny with those of Theophrastus, that the same materials for colouring were employed at Rome and at Athens.

With regard to the nature of these pigments, we may obtain some information from the works of Theophrastus, Dioscorides, Vitruvius, and Pliny; but until the present memoir by Sir H. Davy, no experimental attempt had been made to identify them, or to imitate such of them as are peculiar.

His experiments, he informs us, were made upon colours found in the Baths of Titus, and the ruins called the Baths of Livia, and in the remains of other palaces and baths of ancient Rome, and in the ruins of Pompeii.

By the kindness of his friend Canova, who was charged with the care of the works connected with ancient art in Rome, he was enabled to select, with his own hands, specimens of the different pigments that were found in vases discovered in the excavations made beneath the ruins of the palace of Titus, and to compare them with the colours fixed on the walls, or detached in fragments of stucco; and Signor Nelli, the proprietor of the "Nozze Aldobrandine,"* permitted him to make such experiments upon the colours of that celebrated picture, as was necessary to determine their nature.

Without entering into the chemical details of the subject, I shall offer a general history of the nature of the colours he examined.

Of the red colours, he distinguished four distinct kinds, viz.—one bright and approaching to orange, which he found to be *Minium*, or the red oxide of lead; a second, dull red, which he ascertained to be an iron ochre; a third, a purplish red, which was likewise an ochre, but of a different tint; and a fourth, a brighter red than the first, which was *Vermilion* or *Cinnabar*, a sulphuret of mercury. On examining the fresco paintings in the Baths of Titus, he found that all the three first colours had been used, the ochres particularly, in the shades of the figures, and the minium in the ornaments on the borders. The fourth red had been employed in various apartments, and formed the basis of the colouring of the niche, and of other parts of the chamber in which

* The most celebrated picture of antiquity rescued from the ruins of Herculaneum. It represents a virgin on her marriage night, with her female attendants. An engraving of it is to be seen in Sir William Hamilton's work on Herculaneum.

the Laocoon is said to have been found in the time of Raphael; a circumstance which Davy considers as being favourable to the belief that such apartments were intended for Imperial use, since vermilion, amongst the Romans, was a colour held in the highest esteem, and was always one of great costliness.

Of the yellows, the more inferior were mixtures of ochre and different quantities of chalk; the richer varieties were ochres mixed with the red oxide of lead.

The ancients had also two other colours, which were orange, or yellow; the auripigmentum, or αρσενικον, said to approach to gold in the brilliancy of its tint, and which is described by Vitruvius as being found native in Pontus, and which Davy says was evidently sulphuret of arsenic;—and a pale sandarach, said by Pliny to have been found in gold and silver mines, and which was imitated at Rome by a partial calcination of cerusse. He conceives that this must have been *Massicot*, or the yellow oxide of lead mixed with minium; I suspect, however, that Davy was mistaken in supposing that the ancients always applied the term Sandarach to minium; the Σανδαρακη of Aristotle was evidently an arsenical sulphuret.

In his examination of the ancient Frescoes, he could not detect the use of orpiment; but a deep yellow, approaching to orange, which covered a piece of stucco in the ruins near the monument of Caius Cestius, proved to be oxide of lead, and consisted of massicot and minium. He considers it probable that the ancients used many colours from lead of different tints, between the "*usta*" of Pliny, which was our minium, and imperfectly decomposed cerusse, or pale massicot.

The differently shaded blues, by the action of acids, uniformly assumed the same tint; from which he concluded that the effect of the base was varied by different proportions of chalk. This base he ascertained to be a *frit*, made by means of soda and sand, and coloured by oxide of copper.

The greens were, in general, combinations of copper; and it seemed probable, that although they appeared in the state of carbonate, they might originally have been laid on in that of acetate. The purple of the ancients, the πορφορα of the Greeks, and the *Ostrum* of the Romans, was regarded as their most beautiful colour, and was obtained from shell-fish. Vitruvius states that it was prepared by beating the fish with instruments of iron, freeing the purple liquor from the shell containing it, and then mixing it with a little honey. Pliny says that, for the use of the painters, *argentine creta*, (probably a clay used for polishing silver,) was dyed with it, and both Vitruvius and Pliny state that it was adulterated, or imitations of it made by tinging *creta* with madder; whence it would appear, that the ancients were acquainted with the art of making a lake colour from that plant, similar to the one used by modern painters.

Pliny informs us, that the finest purple had a tint like a deep-coloured rose. In the Baths of Titus, there was found a broken vase of earthenware, which contained a pale rose colour; and Davy selected it as an appropriate subject for his analytical experiments.

Where this colour had been exposed to the action of the air, its tint had faded into a cream colour, but the interior parts retained a lustre approaching to that of carmine. A diluted acid was found to dissolve out of it a considerable quantity of carbonate of lime, with which the colouring principle must have been mixed, as a substance of a bright rose colour remained after the process. This colouring ingredient was proved to contain siliceous, aluminous, and calcareous earths, without any sensible trace of metallic matter, except oxide of iron. Upon heating the substance, first in oxygen, and then with hyperoxymuriate of potash, Davy was induced to consider the colouring matter itself as either of vegetable or animal origin; the results, however, were so equivocal, that he renounced the hope of determining its nature from the products of its decomposition. If it be of animal origin, he thinks it is most probably the Tyrian or marine purple, as it is likely that the most expensive colour would have been employed in ornamenting the imperial baths.

He had not observed any colour of the same tint as this ancient lake in the fresco paintings; the purplish reds in the Baths of Titus he ascertained to be mixtures of red ochres and the blues of copper.

The blacks and browns were mixtures of carbonaceous matter, with the ores of iron or manganese. The black from the Baths of Titus, as well as that from some ruins near the Porta del Popolo, deflagrated with nitre, and presented all the character of carbon. This fact agrees with the statements of all the ancient authors who have described the artificial Greek and Roman black as consisting of carbonaceous matter, either prepared from the powder of charcoal, from the decomposition of resin, (a species of lamp black) from that of the lees of wine, or from the common soot of wood fires. Pliny also mentions the inks of the cuttle-fish, but adds, "*Ex his non fit.*"

Davy informs us, that, some years before, he had examined the black matter of the cuttle-fish, and had found it to be a carbonaceous substance mixed with gelatine.*

Pliny, moreover, speaks of ivory black invented by Apelles; of a natural fossil black; and of a black prepared from an earth of the colour of sulphur. Davy is of opinion, that both these latter pigments were ores of iron and manganese; and he observes that the analysis of some purple glass satisfied him that the ancients were well acquainted with the ores of manganese.

The *whites* which he examined from the Baths of Titus, as well as those from other ruins, were either chalk, or fine aluminous clay; and he states that, amongst all his researches, he never once met with cerusse.

This interesting account of the colours used by the ancients is followed by observations on the manner in which they were applied; and the paper is concluded with some general remarks of much practical importance.

The azure, he says, of which the excellence is sufficiently proved by its duration for 1700 years, may be easily and cheaply imitated: he found, for instance, that fifteen parts of carbonate of soda, twenty parts of opaque flint powdered, and three parts of copper filings, by weight, when strongly heated together for two hours, yielded a compound substance of exactly the same tint, and of nearly the same degree of fusibility; and which, when powdered, produced a fine deep sky-blue.

The azure, the red and yellow ochres, and the blacks, appear to have been the only pigments which have not undergone any change in the fresco paintings. The vermilion presents a darker hue than that of recently made Dutch cinnabar; and the red lead is inferior in tint to that sold in the shops. The greens are generally dull.

The blue frit above mentioned, he considers as a colour composed upon the truest principles; and he thinks there is reason to believe, that it is the colour described by Theophrastus as the one manufactured at Alexandria. " It embodies," says he, " the colour in a composition like stone, so as to prevent the escape of elastic matter from it, or the decomposing action of the elements upon it." He suggests the possibility of making other *frits*, and thinks it would be worth while to try whether the beautiful purple given by oxide of gold could not be made useful in a deeply tinted glass.

* I find from a note addressed by Davy to Mr. Underwood, that he was engaged in these experiments in October 1801.

Where *frit* cannot be employed, he observes that metallic combinations which are insoluble in water, and which are saturated with oxygen or some acid matter, have been proved by the testimony of seventeen centuries to be the best pigments. In the red ochres, for example, the oxide of iron is fully combined with oxygen and carbonic acid; and the colours composed of them have never changed. The carbonates of copper, which consist of an oxide and an acid, have suffered but little alteration. Massicot and orpiment, he considers as those which have been the least permanent amongst all the mineral colours.

He next takes a view of the colours which owe their origin to the improvements of modern chemistry. He considers the *patent yellow* to be more permanent, and the chromate of lead more beautiful, than any yellow possessed by the Greeks or Romans. He pronounces *Scheele's green* (arsenite of copper), and the insoluble muriatic combinations of copper, to be more unalterable than the ancient greens; and he thinks that the sulphate of baryta offers a white far superior to any pigment possessed by the ancients.

In examining the colours used in the celebrated Nozze Aldobrandine, he recognised all the compounds which his analytical enquiries had established: viz. the reds and yellows were all ochres; the blues, the Alexandrian frit; the greens, copper; the purple, especially that in the garment of the Pronuba, appeared to be a compound colour of red ochre and copper; the browns and blacks were mixtures of ochres and carbon; while the whites were carbonate of lime.

"The great Greek painters," he adds, "like the most illustrious artists of the Roman and Venetian school, were probably sparing in the use of the more florid tints in historical and moral painting, and produced their effects rather by the contrasts of colouring in those parts of the picture where a deep and uniform tint might be used, than by brilliant drapery.

"If red and yellow ochres, blacks and whites, were the pigments most employed by Protogenes and Apelles, so they are likewise the colours most employed by Raphael and Titian in their best style. The St. John and the Venus, in the tribune of the Gallery at Florence, offer striking examples of pictures in which all the deeper tints are evidently produced by red and yellow ochres, and carbonaceous substances.

"As far as colours are concerned, these works are prepared for that immortality which they deserve; but unfortunately, the oil and the canvass are vegetable materials, and liable to decomposition, and the last is even less durable than the wood on which the Greek artists painted their celebrated pictures.

"It is unfortunate that the materials for receiving those works which are worthy of passing down to posterity as eternal monuments of genius, taste, and industry, are not imperishable marble or stone:* and that *frit*, or unalterable metallic combinations have not been the only pigments employed by great artists; and that their varnishes have not been sought for amongst the transparent compounds† unalterable in the atmosphere.

In his memoir "On a solid compound of Iodine and Oxygen," he enumerates, amongst the agencies of that body, its singular property of forming crystalline combinations with all the fluid or solid acids. It will be unnecessary to follow him through this investigation, since its results have been found to be erroneous. M. Serullas ‡ has lately shown that the crystalline bodies of Davy are nothing more than the iodic acid, which being insoluble in acids, is necessarily precipitated by them.

His paper "On the action of Acids on Salts usually called Hyper-oxymuriates," announced the important fact of chlorine forming with oxygen a compound, in which the latter element exists in a still greater proportion than in the body previously described by him under the name of *Euchlorine*. §

Before finally quitting Italy, he spent three weeks at Naples, during which period he experimented on iodine and fluorine in the house of Sementini; he also paid several visits to Vesuvius, and found the appearances of the crater to be entirely different from those which it presented in the preceding year; || there was, for instance, no aperture in it; it was often quiet for minutes together, and then burst out into explosions with considerable violence, sending fluid lava, and ignited stones and ashes, to a height of many hundred feet, in the air.

"These eruptions," says he, "were preceded by subterraneous thunder, which appeared to come from a great distance, and which sometimes lasted for

* Copper, it is evident from the specimens in the ruins of Pompeii, is a very perishable material; but modern science might suggest some voltaic protection.

† Davy thinks that the artificial hydrat of alumina will probably be found to be a substance of this kind; and that, possibly, the solution of boracic acid in alcohol will form a varnish. He also thinks, that the solution of sulphur in alcohol is worthy of an experiment.

‡ Annales de Chimie, t. 43. p. 216.

§ See page 208. || See page 287.

a minute. During the four times that I was upon the crater, in the month of March, I had at last learnt to estimate the violence of the eruption from the nature of the sound: loud and long continued subterraneous thunder indicated a considerable explosion. Before the eruption, the crater appeared perfectly tranquil; and the bottom, apparently without an aperture, was covered with ashes. Soon, indistinct rumbling sounds were heard, as if at a great distance; gradually, the sound approached nearer, and was like the noise of artillery fired under our feet. The ashes then began to rise and to be thrown out with smoke from the bottom of the crater; and lastly, the lava and ignited matter was ejected with a most violent explosion. I need not say, that when I was standing on the edge of the crater, witnessing this phenomenon, the wind was blowing strongly from me; without this circumstance, it would have been dangerous to have remained in such a situation; and whenever from the loudness of the thunder the eruption promised to be violent, I always ran as far as possible from the seat of danger.

"As soon as the eruption had taken place, the ashes and stones which rolled down the crater seemed to fill up the aperture, so that it appeared as if the ignited and elastic matter were discharged laterally; and the interior of the crater assumed the same appearance as before."

On the 21st of March, he quitted Naples, and returned to England by the following route: Rome—Narni—Nocere—Fessombone—Imola—Mantua—(March 30,) Verona—Pero—Trente—Botzen—Brennah—Inspruck—Zirl—(April 4,) Reuti-Menningen—Ulm—(April 6,) Stutgard—Heidelburg—Mayence—Boppert—Coblentz—Cologne—(April 14,) Leuch—Brussels—Ostend—Dover—London, April 23, 1815.

CHAPTER XI.

Collieries of the North of England.—Fire-damp.—The dreadful explosion at Felling Colliery described.—Letters from the Bishop of Bristol to the Author.—A Society is established at Bishop-Wearmouth for preventing accidents in coal mines.—Various projects for ensuring the miner's safety.—The Reverend Dr. Gray, the present Bishop of Bristol, addresses a letter to Sir H. Davy, and invites his attention to the subject.—Sir H. Davy's reply.—Farther correspondence upon the possibility of devising means of security.—Sir H. Davy proposes four different kinds of lamp for the purpose.—The Safe-lamp—The Blowing-lamp—The Piston-lamp—The Charcoal-lamp.—His investigation of the properties of fire-damp leads to the discovery of a new principle of safety.—His views developed in a paper read before the Royal Society on the 9th of November 1815.—The first Safety-lamp.—Safety-tubes superseded by Safety-canals.—Flame Sieves.—Wire-gauze lamp.—The phenomenon of slow Combustion, and its curious application.—The invention of the Safety-lamp claimed by a Mr. Stephenson.—A deputation of Coal-owners wait upon Sir H. Davy, in order to express to him the thanks of the Proprietors for his discovery.—Mr. Buddle announces to Dr. Gray (now Bishop of Bristol) the intention of the Coal trade to present him with a service of plate.—The Resolutions are opposed, and the claims of Stephenson urged, by Mr. W. Brandling.—A dinner is given to Sir Humphry, at which the plate is presented to him.—The President and Council of the Royal Society protest against the claims still urged by Mr. Stephenson's friends.—Mr. Buddle's letter in answer to several queries submitted to him by the Author.—Davy's Researches on Flame.—He receives from the Royal Society the Rumford Medals.—Is created a Baronet.—Some observations on the apathy of the State in rewarding scientific merit.—The Geological Society of Cornwall receives the patronage and support of Sir Humphry.

A few months after the return of Sir Humphry Davy to England, his talents were put in requisition to discover some remedy for an evil which had hitherto defied the skill of the best practical engineers and mechanics of the kingdom, and which continued to scatter misery and death amidst an important and laborious class of our countrymen.

To collect and publish a detailed account of the numerous and awful accidents which have occurred within the last few years, from the explosion of inflammable air, or *fire-damp*, in the coal mines of the North of England, would present a picture of the most appalling nature. It appears from a statement by Dr. Clanny, in the year 1813,* that, in the space of seven years, upwards of three hundred pitmen had been suddenly deprived of their lives, besides a considerable number who had been severely wounded; and that more than three hundred women and children had been left in a state of the greatest distress and poverty; since which period the mines have increased in depth, and until the happy discovery of Davy, the accidents continued to increase in number.

It may well be asked how it can possibly have happened that, in a country so enlightened by science and so distinguished for humanity, an evil of such fearful magnitude, and of such frequent recurrence, should for so long a period have excited but little sympathy, beyond the immediate scene of the catastrophe. It would seem that a certain degree of doubt and mystery, or novelty, is essentially necessary to create that species of dramatic interest by which the passions are excited through the medium of the imagination: it is thus that the philanthropist penetrates unknown regions, in search of objects for his compassion, while he passes unheeded the miserable groups who crowd his threshold; it is thus that the statesman pleads the injuries of the Negro with an eloquence that shakes the thrones of kings, while he bestows not a thought upon the intrepid labourers in his own country, who for a miserable pittance pass their days in the caverns of the earth, to procure for him the means of defying the severity of winter, and of chasing away the gloom of his climate by an artificial sunshine.

That the benefits conferred upon mankind by the labours of Sir H. Davy may be properly appreciated, it is necessary to describe the magnitude of the evil which his genius has removed, as well as the numerous difficulties which opposed his efforts and counteracted his designs.

The great coal field,† the scene of those awful accidents which will be hereafter described, extends over a considerable part of the counties of Northumberland and Durham. The whole surface has been calculated at a hundred and eighty square miles, and the number of different beds of coal has been stated to exceed forty; many of which, however, are insignificant in point of dimensions. The two most important are about six feet in thickness, and

* Phil. Transact. 1813.

† Dr. Thomson has calculated that the quantity of coal exported yearly from this formation exceeds two millions of chaldrons; and he thinks it may be fairly stated, in round numbers, that, at the present rate of waste, it will continue to supply coal for a thousand years! Mr. Phillips, however, is inclined to deduct a century or two from this calculation.

are distinguished by the names of *High main*, and *Low main*, the former being about sixty fathoms above the latter.

From this statement some idea may be formed of the great extent of the excavations, and of the consequent difficulty of successfully ventilating the mines. In some collieries, they are continued for many miles, forming numerous windings and turnings, along which the pitmen have frequently to walk for forty or fifty minutes, before they arrive at the workings; during which time, as well as when at work, they have no direct communication with the surface of the earth. The most ingenious machinery, however, has been contrived for conducting pure air through every part of the mine, and for even ventilating the old excavations, which are technically called *Wastes;* and unless some obstruction occur, the plan * so far answers, as to furnish wholesome air to the pitmen, and to diminish, although, for reasons to be hereafter stated, it can never wholly prevent, the dangers of *fire-damp;* the nature of which it will be necessary to consider.

The coal appears to part with a portion of *carburetted hydrogen*, when newly exposed to the atmosphere; a fact which explains the well-known circumstance of the coal being more inflammable when fresh from the pit, than after long exposure to the air. We are informed by the Reverend Mr. Hodgson that, on pounding some common Newcastle coal fresh from the mine, in a cask furnished with a small aperture, he found the gas which issued from it to be inflammable; and Davy, on breaking some lumps of coal under water, also ascertained that they gave off inflammable gas. The supposition that the coal strata have been formed under a pressure greater than that of the atmosphere, may furnish a clue to the comprehension of this phenomenon.

On some occasions the pitmen have opened with their picks crevices, or fissures, in the coal or shale, which have emitted as much as seven hundred hogsheads of *fire-damp* in a minute. These *Blowers*, as they are technically termed, have been known to continue in a state of activity for many months, or even years together;† a phenomenon which clearly shows that the carburetted hydro-

* In all large collieries, the air is accelerated through the workings by placing furnaces, sometimes at the bottom, and sometimes at the top of the up-cast shaft; in aid of which, at Wall's-end Colliery, a powerful air-pump worked by a steam-engine is employed to quicken the draft: this alone draws out of the mines a thousand hogsheads of air every minute. Stoppings and trap-doors are also interposed in various parts of the workings, in order to give a direction to the draft.

† Sir James Lowther found a uniform current of this description produced in one of his mines for the space of two years and nine months. Phil. Trans. vol. 38. p. 112.

gen must have existed in the cavities of the strata in a very highly compressed, if not actually in a liquid state, and which, on the diminution of pressure, has resumed its elastic form.

All the sources of carburetted hydrogen would appear to unite in the deep and valuable collieries situated between the great North road and the sea. Their air courses are thirty or forty miles in length; and here, as might be expected, the most tremendous explosions have happened. Old workings, likewise, upon being broken into, have not unfrequently been found filled with this gas, and which, by mingling itself with the common air, has converted the whole atmosphere of the mine into a magazine of *fire-damp*.

On the approach of a candle, it is in an instant kindled: the expanded fluid drives before it a roaring whirlwind of flaming air, which tears up every thing in its progress, scorching some of the miners to a cinder, and burying others under enormous ruins shaken from the roof; when thundering to the shafts, it converts the mine, as it were, into an enormous piece of artillery, and wastes its fury in a discharge of thick clouds of coal-dust, stones, and timber, together with the limbs and mangled bodies of men and horses.

But this first, though apparently the most appalling, is not the most destructive effect of these subterraneous combustions. All the *stoppings* and trap-doors of the mine being blown down by the violence of the concussion, and the atmospheric current entirely excluded from the workings, such of the miners as may have survived the discharge are doomed to the more painful and lingering death of suffocation from the *after-damp*, or *stythe*, as it is termed, which immediately results from the combustion, and occupies the vacuum necessarily produced by it.

As the phenomena accompanying these explosions are always of the same description, to relate the numerous recorded histories of such accidents would be only to multiply pictures of death and human suffering, without an adequate object: it is, however, essential to the just comprehension of the subject, that the reader should receive at least one well-authenticated account, in all its terrific details; and I have accordingly selected that which was originally drawn up with much accuracy and feeling by the Reverend John Hodgson, and which is prefixed to the funeral sermon preached on the occasion, and subsequently published by that gentleman.

The accident occurred at Felling Colliery, near Sunderland, on the 25th of May, in the year 1812. This mine was considered by the workmen as a model of perfection, both with regard to the purity of its air, and the arrangements of its machinery. The concern was in the highest degree prosperous; and no accident, except a trifling explosion which slightly scorched two or three pitmen, had ever occurred.

Two *shifts*, or sets of men, were constantly employed, the first of which entered the mine at four, and were relieved at their working posts by the next set at eleven o'clock in the morning; but such was the confidence of the pitmen in the safety of this mine, that the second shift of men were often at their posts before the first set had left them; and such happened to be the case on the following unhappy occasion.

About half past eleven, on the morning of the 25th of May, the neighbouring villages were alarmed by a tremendous explosion. The subterraneous fire broke forth with two heavy discharges from the shaft called the '*John Pit*,' which was one hundred and two fathoms deep, and were almost immediately followed by one from that termed the '*William Pit*.' A slight trembling, as if from an earthquake, was felt for about half a mile around the workings; and the noise of the explosion, though dull, was heard to the distance of three or four miles, and greatly resembled an unsteady fire of infantry.

Immense quantities of dust and small coal accompanied these blasts, and rose high into the air, in the form of an inverted cone. The heaviest part of the ejected matter, such as masses of timber, and fragments of coal, fell near the pit, but the dust borne away by a strong west wind, fell in a continued shower to the distance of a mile and a half; and in the village of Heworth, it caused a gloom, like that of early twilight, and so covered the roads that the footsteps of passengers were strongly imprinted on them.

As soon as the explosion had been heard, the wives and children of the pitmen rushed to the working pit. Wildness and terror were pictured in every countenance. The crowd thickened from every side, and in a very short period several hundred persons had collected together; and the air resounded with exclamations of despair for the fate of husbands, parents, and children.

The machinery having been rendered useless by the eruption, the rope of the *gin* was sent down the shaft with all possible expedition. In the absence of horses, a number of men, who seemed to acquire strength as the necessity for it increased, applied their shoulders to the *starts*, or shafts of the gin, and worked it with astonishing expedition.

By twelve o'clock, thirty-two persons, all that survived this dreadful catastrophe, had been brought to daylight, but of these three boys lived only a few hours. The dead bodies of two boys, miserably scorched and shattered, were also brought up at the same time; twenty-nine persons then were all who were left to relate what they had observed of the appearances and effect of the explosion; one hundred and twenty-one were in the mine when it happened, eighty-seven of whom remained in the workings, eight persons having fortunately come up a short time before the accident.

Those who had their friends restored, hastened with them from the scene of destruction, and for a while appeared to suffer as much from an excess of joy, as they had a short time before from the depth of despair; while those who were yet in the agony of suspense, filled the air with shrieks and howlings, and ran about wringing their hands and throwing their bodies into the most frantic and extravagant gestures.

As not one of the pitmen had escaped from the mine by the only avenue open to them, the apprehension for their safety momentarily increased, and at a quarter after twelve o'clock, nine persons descended the John pit, with the faint hope that some might still survive.

As the fire-damp would have been instantly ignited by candles, they lighted their way by *steel-mills* ;* and knowing that a great number of the miners must have been at the crane when the explosion happened, they at once attempted to reach that spot: their progress, however, was very soon intercepted by the prevalence of *choak damp*, and the sparks from their steel-mill fell into it like dark drops of blood: deprived therefore of light, and nearly suffocated by the noxious atmosphere, they retraced their steps towards the shaft, but they were shortly stopped by a thick smoke which stood like a wall before them. Here their steel-mills became entirely useless, and the chance of their ever finding any of their companions alive entirely hopeless; to which should also be added the horror arising from the conviction of the mine being on fire, and the probability of a second explosion occurring at the next moment, and of their being buried in the ruins it would occasion.

At two o'clock, five of the intrepid persons who had thus nobly volunteered their assistance, ascended; two were still in the shaft, and the other two remained below, when a second explosion, much less severe, however, than the first, excited amongst the relatives of those entombed in the mine still more frightful expressions of grief and despair. The persons in the shaft

* Steel-mills are small machines, which give light by turning a cylinder of steel against a piece of flint. Sir James Lowther had observed early in the last century, that the fire-damp in its usual form was not inflammable by sparks from flint and steel; and it appears that a person in his employment invented the machine in question.

experienced but little inconvenience from this fresh eruption, while those below, on hearing the distant growlings, immediately threw themselves flat on their faces, and in this posture, by keeping a firm hold on a strong wooden prop, they felt no other annoyance from the blast than that of having their bodies tossed in various directions, in the manner that a buoy is heaved by the waves of the sea. As soon as the atmospheric current returned down the shaft, they were safely drawn to the light.

As each came up, he was surrounded by a group of anxious enquirers; but not a ray of hope could be elicited; and the second explosion so strongly corroborated their account of the impure state of the mine, that their assertions for the present seemed to obtain credit. This impression, however, was but of short duration,—hope still lingered; they recollected that persons had survived similar accidents, and that, upon opening the mine, they had been found alive after considerable intervals. Three miners, for instance, had been shut up for forty days in a pit near Byker, and during the whole of that period had subsisted on candles and horse-beans. Persons too were not wanting to agitate the minds of the relatives with disbelief in the report of the pitmen who had lately descended to explore the mine. It was suggested to them, that want of courage, or bribery, might have induced them to magnify the danger, and to represent the impossibility of reaching the bodies of the unfortunate sufferers. By this species of wicked industry, the grief of the neighbourhood began to change its gloomy, for an irritable aspect. The proposition to exclude the atmospheric air from the mine, in order to extinguish the fire, was received with the cries of murder!—and with the determination to oppose such a proceeding by violence.

Many of the widows lingered about the mouth of the pit during the whole of the night, with the hope of hearing the cries of a husband or a son.

On Tuesday the 26th, that natural propensity in the human mind to derive gratification from spectacles of horror, was exemplified in a very striking manner. An immense crowd of colliers from various parts, but more especially from the banks of the river Wear, assembled around the pit, and were clamorous in their reproaches of the persons concerned in the management of the mine, accusing them of want of perseverance in their attempts to rescue the unhapy sufferers. Every one had some successful adventure to relate; all were liberal in their professions of readiness to give assistance; but not one was found hardy enough to enter the jaws of the burning cavern.

The leaders of this outcry, however, who had been led into error by an impulse which did honour to their hearts, were soon brought to listen with patience to a relation of all the circumstances of the explosion, and of the reasons for concluding that the mine was then actually on fire, and the persons enclosed in it beyond the hope of recovery. They very candidly allowed, after this explanation, the impracticability of any attempt to reach the bodies of the sufferers, until the fire was extinguished; and they accordingly urged the propriety of excluding from the mine the access of air, as the only means of accomplishing the object. At the same time, the proprietors gave the strongest assurances to the multitude, that if any project could be devised for the recovery of their friends, no cost or labour should be spared in executing it; that, if any person could be found willing to enter the mine, every facility and assistance should be afforded him; but, as they were assured by the most eminent Viewers that the workings were inaccessible, they would not hold out any reward for the attempt,—they would not be accessary to the death of any one, either by persuasion or bribery.

At the clamorous solicitation, however, of the populace, two persons again descended the shaft, and very nearly lost their lives in the attempt. The report of these last adventurers, in a great measure, convinced the people of the impossibility of their friends' survival in so deadly an atmosphere, and reconciled them to the plan of excluding the air. The operation was accordingly commenced, and it proceeded without interruption; but from various accidents, more than a month elapsed before the mine was in a state to admit of examination; and during this interval, numerous were the idle tales which had been circulated throughout the country. Several of the sufferers, it was said, had found their way to the shafts, and been recovered. Their number even had been circumstantially told—how they had subsisted on candles, oats, and beans, and how they had heard the different persons who explored the mine in the hope of rescuing them.

Some conjuror too, it was said, had set his spells and divinations to work, and had penetrated all the secrets of the mine. He had discovered one famishing group receiving drops of water from the roof, another eating their shoes and clothes, and many other similar pictures of horror. These inventions were carefully related to the widows, and they produced the effect of daily harrowing up afresh their sorrows; indeed, it seemed the chief employment of some to indulge in a kind of insane sport with their own and their neighbours' calamity.

The morning of Wednesday the 8th of July having been appointed for exploring the workings, the distress of the neighbourhood was again renewed at an early hour; a great concourse of people assembled; some, out of curiosity, to witness the commencement of an undertaking full of sadness and danger,—some to excite the revenge, or to aggravate the sorrows, of the relatives by calumnies and reproaches, for the sole purpose of mischief; but the greater part came with broken hearts and streaming eyes, in expectation of seeing the mangled corpse of a father, brother, husband, or son.

The *shifts* of men employed in this doleful and unwholesome work were generally about eight in number. They were four hours in, and eight hours out of the mine; so that each individual wrought two shifts every twenty-four hours.

When the first shift of men came up, a message was dispatched for a number of coffins to be in readiness at the mouth of the pit. Ninety-two had been prepared, and they had to pass by the village of Low Felling, in their way to the mine. As soon as a cart-load of them was seen, the howling of the women, who, hitherto secluded in their dwellings, had now begun to assemble about their doors, came on the breeze in slow fitful gusts, which presaged a scene of the greatest distress and confusion.

The bodies were found under various circumstances: one miner, from his position, must have been sleeping when the explosion happened, and had never opened his eyes. In one spot were found twenty-one bodies in ghastly confusion,—some like mummies, scorched as dry as if they had been baked; one wanted its head, another an arm — the scene was most terrific: the power of the fire was visible upon all, but its effects were very various; while some were almost torn to pieces, there were others who appeared as if they had sunk down overpowered by sleep.

Every family had made arrangements for receiving the dead bodies of their kindred; but Dr. Ramsay having given his opinion, that such a proceeding might spread a putrid fever through the neighbourhood, and the first body when exposed to observation having presented a most horrid and corrupt appearance, the people very properly consented to have each body interred as soon as it was discovered, on condition that the hearse, in its way to the chapel yard, should pass by the door of the deceased.

From the 8th of July to the 19th of September, the heart-rending scene of mothers and widows examining the putrid bodies of their sons and husbands, for marks by which to identify them, was daily renewed; but very few of them were recognised by any personal mark—they were too much mangled and scorched to retain any of their features: their clothes, tobacco-boxes, and shoes, were therefore the only indications by which they could be identified.

The total loss from this terrible accident was ninety-two pitmen;—while forty widows, sixty girls, and twenty-six boys, comprising in all one hundred and twenty-six persons, were thrown upon the benevolence of the public.

It was impossible that an event of such awful magnitude should not have deeply affected every humane person resident in the district. Nothing, in short, could exceed the anxiety which was manifested on the occasion; but, most unfortunately, there existed an invincible prejudice against every proposition that could be offered, from a general impression as to the utter hopelessness of any attempt to discover a remedy. A few philosophic individuals, however, did form themselves, as we shall presently learn, into an association for the laudable purpose of inviting the attention of scientific men to the subject, and of obtaining from them any suggestions which might lead to a more secure method of lighting the mines.

To the Reverend Dr. Gray, the present Lord Bishop of Bristol, who, at the period to which I allude, was the Rector of Bishop-Wearmouth, and one of the most zealous and intelligent members of the association, I beg to offer my public acknowledgments and thanks for the several highly interesting communications and letters with which his Lordship has obliged me, and by means of which I have been enabled to present to the scientific world a complete history of those proceedings which have so happily led to a discovery, of which it is not too much to say that it is, at once, the pride of science, the triumph of humanity, and the glory of the age in which we live.

In a letter I had lately the honour of receiving from that learned prelate, his Lordship says, "It was at a time when all relief was deemed hopeless, that Mr. Wilkinson, a barrister in London, and a gentleman distinguished for the humanity of his disposition, suggested the expediency of establishing a society for the purpose of enquiring whether any, and what, methods of security might be adopted for the prevention of those accidents so frequently occurring in the collieries of Northumberland and Durham.

"In consequence of this benevolent suggestion, a Society was established at Bishop-Wearmouth, on the 1st of October 1813, by Sir Ralph Milbanke, afterwards Sir Ralph Noel, Dr. Gray, Dr. Pemberton, Mr. Robinson, Mr. Stephenson, and several other gentlemen. It was entitled, 'A Society for preventing Accidents in Coal-Mines;' and it immediately obtained the patronage of the Bishop of Durham, the Duke of Northumberland, and other noblemen and gentlemen.

"A very few days before the first meeting, twenty-seven persons had been killed in a colliery in which Sir Ralph Milbanke had an interest, and he was called upon at the meeting to state the particulars of the accident. At that time there was such little expectation that any means could be devised to prevent the occurrence of these explosions, that the object of the gentlemen who convened the meeting, however humane in principle, was considered by the persons present as chimerical and visionary. The Society, however, amidst many difficulties and considerable discouragement, and a perpetual harass by the offer of impracticable schemes from every quarter, nevertheless persevered in their meetings, and succeeded in establishing a communication and correspondence with other Societies in different parts of the kingdom." *

"One of the projects offered was, that electrical machines should be employed, with ramifications to extend through all the departments of the collieries, and which were to be excited in discharging their fluid in constant suc-

* It is unnecessary to enumerate the various schemes that have been proposed to prevent accidents from fire-damp. Some were unquestionably of value, and might, by their adoption, have diminished the frequency of explosions; others were visionary, or wholly impracticable. It was proposed, for instance, to fill the mine with an atmosphere of chlorine, which by entering into chemical union with the carburetted hydrogen, might disarm it of its power. Dr. Murray, in a paper published in the Transactions of the Royal Society of Edinburgh, suggests the use of a lamp that shall be supplied with air from the ground of the pit, by means of a long flexible tube, upon the false assumption that the fire-damp alone occupies the higher parts of the mine. Mr. W. Brandling also constructed a Safe-lamp, which, like that of Dr. Murray, was fed by air introduced through a long flexible tube reaching to the floor of the mine. In addition to which, he attached to the top of the lantern a pair of double bellows, by the aid of which he at the same time drew out the contaminated air from the interior of the lamp, and sucked in, through the flexible tube, a fresh portion to supply its place. To say nothing of the inefficacy and inconvenience of the long tube, the bellows possessed the additional objection of frequently puffing out the light.

One of the most active and intelligent members of the "Society for preventing accidents in Coal Mines," Dr. Clanny, had for some time paid particular attention to the object in contemplation. He first suggested the idea of an insulated lamp, of which an account appeared in the Philosophical Transactions for 1813. In 1815, he invented a steam safety-lamp, constructed of the strongest tinned iron, with thick flint glass in front. In this machine, the air of the coal mine passes in a current through a tube, and mixing with the steam, before it can arrive at the light, burns steadily in the wick of the lamp alone. This lamp has the valuable property of remaining cool. It has been much used in the Herrington Mill-pit, the Whitefield-pit, and the Engine-pit.

cession, in order gradually to destroy the inflammable air. Many other suggestions were proposed, the principal of which were formed with the intention of purifying the air of the pits by chemical processes, or by forcing in large quantities of atmospheric air, through pipes and tunnels, &c.

" The Society, although it received some distinguished patronage, was not furnished with means sufficiently ample for exciting emulation by premiums, or even for defraying the expenses of intelligent artisans; and it unfortunately lost a considerable portion of its funds by the failure of the Wear Bank.

" Amongst the applications which more particularly excited the attention of the Society, was that of Mr. Ryan of Donegal, who objected to the principle upon which the working of collieries was carried on. He conceived that they should be originally constructed at the commencement of the working, with a view to admit the escape of the hydrogen gas to the highest parts of the colliery. He proposed to ventilate even the foulest pits, and the attention of the gentlemen proprietors, or occupiers of collieries, in the neighbourhood of Newcastle, was called upon at public meetings, and an enquiry set on foot with respect to the validity of his pretensions. Some gentlemen were even deputed to proceed into Staffordshire to ascertain the nature and extent of his services in that county, where he had been for some time employed. An offer was also made to place under his management the Hecton pit, at Hepburn, which was particularly foul; but a difference of opinion having arisen as to the efficacy of his plan, he did not consider himself sufficiently encouraged to proceed, and he left the country dissatisfied. He afterwards received the gold medal from the Society for promoting the Arts and Sciences."

The Society having as yet effected but little towards the great object of their deliberations, the chairman of the committee, Dr. Gray, who was generally acquainted with Sir Humphry Davy, judged it expedient to direct his attention to a subject, upon which, of all men of science, he appeared to be the best calculated to bring his extensive stores of chemical knowledge to a practical bearing.

As the life of this valuable man is now closed, and as every incident in it is interesting as connected with the advancement of philosophical knowledge, and especially of chemical discoveries important to the welfare of mankind, it may be worth while to enter into a review of the proceedings which were adopted upon this occasion, in order to trace the progress of the discoveries which were made, and the methods by which he arrived at his conclusions.

Dr. Gray, the chairman of the committee, having addressed to him a letter with a view to engage him in an investigation so important to society, received from him the following answer :—

TO THE REVEREND DR. GRAY.

SIR, August 3, 1815.

I HAD the honour of receiving the letter which you addressed to me in London, at this place, and I am much obliged to you for calling my attention to so important a subject.

It will give me great satisfaction if my chemical knowledge can be of any use in an enquiry so interesting to humanity, and I beg you will assure the Committee of my readiness to co-operate with them in any experiments or investigations on the subject.

If you think my visiting the mines can be of any use, I will cheerfully do so.

There appears to me to be several modes of destroying the fire-damp without danger; but the difficulty is to ascertain when it is present, without introducing lights which may inflame it. I have thought of two species of lights which have no power of inflaming the gas which is the cause of the fire-damp, but I have not here the means of ascertaining whether they will be sufficiently luminous to enable the workmen to carry on their business. They can be easily procured, and at a cheaper rate than candles.

I do not recollect any thing of Mr. Ryan's plan: it is possible that it has been mentioned to me in general conversation, and that I have forgotten it. If it has been communicated to me in any other way, it has made no impression on my memory.

I shall be here for ten days longer, and on my return South, will visit any place you will be kind enough to point out to me, where I may be able to acquire information on the subject of the coal gas.

Should the Bishop of Durham be at Auckland, I shall pay my respects to his Lordship on my return.

I have the honour to be, dear Sir, with much respect, your obedient humble servant, H. DAVY.

At Lord Somerville's, near Melrose, N. B.

TO THE SAME.

SIR, Melrose, August 18, 1815.

I RECEIVED your letter, which followed me to the Moors, where I have been shooting with Lord Somerville. I should have replied to it before this time, but we were in a part of the Highlands where there was no post. I am very grateful to you for the obliging invitation it contains.

I propose to leave the Tweed side on Tuesday or Wednesday, so that I shall be at Newcastle either on Wednesday or Thursday. If you will have the kindness to inform me by a letter, addressed at the Post Office, where I can find the gentleman you mention, I will call upon him, and do any thing in my power to assist the investigation in that neighbourhood.

I regret that I cannot say positively whether I shall be at Newcastle on Wednesday or Thursday; for I have some business at Kelso which may detain me for a night, or it may be finished immediately.

I am travelling as a bachelor, and will do myself the honour of paying my respects to you at Bishop-Wearmouth towards the end of the week.

I am, Sir, with much respect, your obedient humble servant,

H. Davy.

The gentleman alluded to in the preceding letter, and to whom Dr. Gray wished Sir H. Davy to apply, was Mr. Buddle, a person whose extensive practical knowledge has justly entitled him to be considered as the highest authority on all subjects connected with the art of mining, and who has conferred inestimable benefits on the mining interests by the introduction of successful methods of ventilation. The account of his interview with Sir H. Davy is communicated in the following letter.

MR BUDDLE TO DR. GRAY.

Sir, Wall's-end Colliery, August 24, 1815.

Permit me to offer my best acknowledgments for the opportunity which your attention to the cause of humanity has afforded me of being introduced to Sir Humphry Davy.

I was this morning favoured with a call from him, and he was accompanied by the Rev. Mr. Hodgson. He made particular enquiries into the nature of the danger arising from the discharge of the inflammable gas in our mines. I shall supply him with a quantity of the gas to analyze; and he has given me reason to expect that a substitute may be found for the steel mill, which will not fire the gas. He seems also to think it possible to generate a gas, at a moderate expense, which, by mixing with the atmospheric current, will so far neutralize the inflammable air, as to prevent it firing at the candles of the workmen.

If he should be so fortunate as to succeed in either the one or the other of these points, he will render the most essential benefit to the mining interest of this country, and to the cause of humanity in particular.

I have little doubt but it will be gratifying to you to be informed, that progress is making towards the establishment of a permanent fund for the relief of sufferers by accident and sickness in the collieries of this district.

I have the pleasure to remain, with great respect, Sir, your most obedient, humble servant, JOHN BUDDLE.

Sir H. Davy on his return to London, having been supplied by Mr. Buddle with various specimens of *fire-damp*, proceeded, in the first instance, to submit to a minute chemical examination the substance with which he had to contend.

In less than a fortnight, he informed Dr. Gray by letter, that he had discovered some new and unexpected properties in the gas, which had led to no less than four different plans for lighting the mines with safety.

TO THE REVEREND DR. GRAY.

Royal Institution, October 30.

MY DEAR SIR,

As it was the consequence of your invitation that I endeavoured to investigate the nature of the fire-damp, I owe to you the first notice of the progress of my experiments.

My results have been successful far beyond my expectations. I shall enclose a little sketch of my views on the subject; and I hope in a few days to be able to send a paper with the apparatus for the committee.

I trust the *Safe lamp* will answer all the objects of the collier.

I consider this at present as a *private* communication. I wish you to examine the lamps I have had constructed, before you give any account of my labours to the committee.

I have never received so much pleasure from the result of any of my chemical labours; for I trust the cause of humanity will gain something by it.

I beg of you to present my best respects to Mrs. Gray, and to remember me to your son.

I am, my dear Sir, with many thanks for your hospitality and kindness when I was at Sunderland, your obliged servant,

H. DAVY.

TO THE SAME.

MY DEAR SIR, London, October 31, 1815.

I SENT yesterday a sketch of my results on the fire-damp. We have lately heard so much of East* Shields, that by a strange accident I confounded it with Bishop-Wearmouth, and addressed your letter to East Shields.

I could not find any body to frank it, and you will find it a heavy packet; however, I could not lose a moment in giving you an account of results which I hope may be useful to humanity.

If my letter has not reached you, it will be found at the Post Office, East Shields.

With respects to Mrs. Gray, I am, my dear Sir, very sincerely yours,

H. DAVY.

The sketch alluded to in the foregoing letter, has been kindly placed in my hands by the Bishop of Bristol; it possesses considerable interest as an original document, displaying his earliest views, and tending to illustrate the history of their progress.

" The fire-damp I find, by chemical analysis, to be (as it has been always supposed) a hydro-carbonate. It is a chemical combination of hydrogen gas and carbon, in the proportion of 4 by weight of hydrogen gas, and $11\frac{1}{2}$ of charcoal.

" I find it will not explode, if mixed with less than six times, or more than fourteen times its volume of atmospheric air. Air, when rendered impure by the combustion of a candle, but in which the candle will still burn, will not explode the gas from the mines; and when a lamp or candle is made to burn in a close vessel having apertures only above and below, an *explosive mixture* of gas admitted *merely enlarges* the light, and then gradually extinguishes it without explosion. Again,—the gas mixed in any proportion with common air, I have discovered, *will not explode* in a *small tube*, the diameter of which is less than $\frac{1}{8}$th of an inch, or even a larger tube, if there is a mechanical force urging the gas through this tube.

" Explosive mixtures of this gas with air require much stronger heat for their explosion than mixtures of common inflammable gas.† Red-hot charcoal,

* *Quere*—South Shields.

† *Olefiant* gas, when mixed with such proportions of common air as to render it explosive, is

made so as not to flame, if blown up by a mixture of the mine gas and common air, does not explode it, but gives light in it; and iron, to cause the explosion of mixtures of this gas with air, must be made *white*-hot.

"The discovery of these curious and unexpected properties of the gas, leads to several practical methods of lighting the mines without any danger of explosion.

"The first and simplest is what I shall call the *Safe lamp*, in which a candle or a lamp burns in a safe lantern which is air-tight in the sides, which has tubes below for admitting air, a chamber above, and a chimney for the foul air to pass through; and this is as portable as a common lantern, and not much more expensive. In this, the light never burns in its full quantity of air, and therefore is more feeble than that of the common candle.

"The second is the *Blowing lamp*. In this, the candle or lamp burns in a close lantern, having a tube below of small diameter for admitting air, which is thrown in by a small pair of bellows, and a tube above of the same diameter, furnished with a cup filled with oil. This burns brighter than the simple safe lamp, and is extinguished by explosive mixtures of the fire-damp. In this apparatus the candle may be made to burn as bright as in the air; and supposing an explosion to be made in it, it cannot reach to the external air.

"The third is the *Piston lamp*, in which the candle is made to burn in a small glass lantern furnished with a piston, so constructed as to admit of air being supplied and thrown into it without any communication between the burner and the external air: this apparatus is not larger than the steel mill, but it is more expensive than the other, costing from twenty-two to twenty-four shillings.

"These lamps are all extinguished when the air becomes so polluted with fire-damp as to be explosive.

"There is a fourth lamp, by means of which any *blowers* may be examined in air in which respiration cannot be carried on, that is, the *Charcoal lamp*. This consists of a small iron cage on a stand, containing small pieces of *very well burnt* charcoal blown up to a red heat. This light will not inflame any mixtures of air with fire-damp.*

fired both by charcoal and iron heated to a dull-red heat. *Gaseous oxide of carbon*, which explodes when mixed with two parts of air, is likewise inflammable by red-hot iron, and charcoal. The case is the same with *sulphuretted hydrogen*.

* In addition to these four lamps, we learn from an Appendix to his Paper in the Philosophical Transactions, that in the beginning of his enquiries, he constructed a close lantern, which he called

"Of these inventions, the *Safe lamp*, which is the simplest, is likewise the one which affords the most perfect security, and requires no more care or attention than the common candle; and when the air in mines becomes improper for respiration, it is extinguished, and the workmen ought immediately to leave the place till a proper quantity of atmospheric air can be supplied by ventilation.

"I have made many experiments on these lamps with the genuine fire-damp taken from a blower in the Hepburn Colliery, collected under the inspection of Mr. Dunn, and sent to me by the Reverend Mr. Hodgson. My results have been always unequivocal.

"I shall immediately send models of the different lamps to such of the mines as are exposed to danger from explosion; and it will be the highest gratification to me to have assisted by my efforts a cause so interesting to humanity."

Contrary to the wish expressed by Sir Humphry Davy, the foregoing communication was inadvertently read at a public meeting of the Coal-trade, which was held at Newcastle on the 3rd of November; a circumstance which occasioned some embarrassment at the time; but is satisfactorily explained in the following letter from Sir Humphry.

TO THE REVEREND DR. GRAY.

MY DEAR SIR, 23, Grosvenor Street, Dec. 14, 1815.

MY communication to ——— was, like that I made to you, intended to be *private;* he has however written to me to apologize for having made it known at Newcastle, stating, that having seen a notice of my results in the paper, the motive, as he conceived, for withholding it was at an end, as he considered my only reason for wishing to keep back my results from the public eye was the conviction that they might be rendered more perfect, and this I have now fully proved.

I trust I shall be able in a very few days to send you a model of a lantern

the *Fire-valve lantern;* in which the candle or lamp burnt with its full quantity of air, admitted from an aperture below, till the air began to be mixed with fire-damp, when as the fire-damp increased the flame, a thermometrical spring at the top of the lantern, made of brass and steel, riveted together, and in a curved form, expanded, moved a valve in the chimney, diminished the circulation of air, and extinguished the flame. He did not, however, pursue this invention, after he had discovered the properties of the fire-damp, on which his Safety-lamp is founded.

nearly as simple as a common glass lantern, and which *cannot* communicate explosion to the fire-damp. I will send another to Newcastle, and I will likewise send you the copy of my paper, which you may reprint in any form you please; you will find my acknowledgments to you publicly stated.

My principles are these: *First*, a certain mixture of azote and carbonic acid prevents the explosion of the fire-damp, and this mixture is necessarily formed in the safe lantern;—*Secondly*, the fire-damp *will not explode* in tubes or feeders of a certain small diameter. The ingress into, and egress of air from my lantern is through such tubes or feeders; and therefore, when an explosion is *artificially* made in the safe lantern, it does not communicate to the external air.

I have made two or three lanterns of different forms. Experience must determine which will be the most convenient.

Should there be a little delay in sending them, it will be the fault of the manufacturer. It is impossible to conceive the difficulty of getting any thing made in London which is not in the common routine of business; and I should be very sorry to send you any thing imperfectly executed.

With best respects to Mrs. Gray, I am, my dear Sir,

Very sincerely your obliged servant,

H. Davy.

The paper alluded to in the preceding letter, entitled, " On the fire-damp of Coal Mines, and on methods of lighting the mine so as to prevent its explosion," was read before the Royal Society on the 9th of November, 1815.

In this memoir he communicates the results of some chemical experiments upon the nature of the fire-damp, and announces the existence of certain properties in that gas, which had previously escaped observation, and which leads to very simple methods of lighting the mines without danger.

He confirms the opinion of Dr. Henry, and other chemists, as to the fire-damp being light carburetted hydrogen gas, and analogous to the inflammable gas of marshes; but he found that the degree of its combustibility differed most materially from that of the other common inflammable gases, which it is well known will explode by the contact of both red-hot iron and charcoal; whereas well-burned charcoal, ignited to the strongest red heat, did not explode any mixture of the air and of the fire-damp; and a fire made of well-burned charcoal, that is to say, of charcoal that will burn without flame, was actually blown up to whiteness by an explosive mixture containing the fire-damp, without producing its inflammation.* An iron rod also, at the highest degree of *red* heat, and even at the common degree of *white* heat, did not inflame explosive mixtures of the fire-damp; but when in brilliant combustion it produced the effect.

He moreover found that the heat produced by the combustion of the fire-damp was much less than that occasioned by most other inflammable gases under similar circumstances; and hence its explosion was accompanied with comparatively less expansion; a circumstance of obvious importance in connection with the propagation of its flame.

Numerous experiments were likewise instituted by him with a view to determine the proportions of air with which the fire-damp required to be mixed, in order to produce an explosive atmosphere; and he found the quantity necessary for that purpose to be very considerable; even when mixed with three or nearly four times its bulk of air, it burnt quietly in the atmosphere, and extinguished a taper. When mixed with between five and six times its volume of air, it exploded freely. The mixture which seemed to possess the greatest explosive power was that of seven or eight parts of air to one of gas.

On adding azote and carbonic acid in different proportions to explosive mixtures of fire-damp, it was observed that, even in very small quantities, these gases diminished the velocity of the inflammation, or altogether destroyed it. In this stage of the enquiry, the important fact was discovered, that explosive mixtures could not be fired in metallic tubes of certain lengths and diameters.† In exploding, for instance, a mixture of one part of gas from the distillation of coal, and eight parts of air, in a tube of a quarter of an inch in diameter and a foot long, more than a second was required before the flame reached from one end of the tube to the other; and not any mixture could be made to explode in a glass tube of one-seventh of an inch in diameter. In pursuing these experiments, he found that, by diminishing its diameter, he might in the same ratio shorten the tube without danger; and that the same

* Whence he observes that, if it be necessary to be present in a part of the mine where the fire-damp is explosive, for the purpose of clearing the workings, taking away pillars of coal, or other objects, the workmen may be safely lighted by a fire made of charcoal, which burns without flame.

† Mr. Tennant had, some years before, observed that mixtures of the gas, from the distillation of coal, and air, would not explode in very small tubes. Davy, however, was not aware of this at the time of his researches.

principle of security was obtained by diminishing the length and increasing the number of the tubes, so that a great number of small apertures would not pass explosion when their depth was equal to their diameter. This fact led him to trials upon sieves made of wire-gauze, or metallic plates perforated with numerous small holes, and he found that it was impossible to pass explosions through them.*

In reasoning upon these several phenomena, it occurred to him, that as a high temperature was required for the inflammation of the fire-damp, and as it produced in burning, comparatively, *a small degree* of heat, the effect of carbonic acid and azote, as well as that of the surfaces of small tubes, in preventing its explosion, depended upon their cooling powers, that is to say, upon their lowering the temperature of the exploding mixture to such a degree, that it was no longer sufficient for its continuous inflammation. In support of this theory, he ascertained that metallic tubes resisted the passage of the flame more powerfully than glass tubes of similar lengths and diameters, metal being the better conductor of heat; and that carbonic acid was more effective than azote in depriving the fire-damp of its explosive power, in consequence, as he considered, of its greater capacity for heat, and likewise of a higher conducting power connected with its greater density.

In this short statement, the reader is presented with the whole theory and operation of the Safety-lamp, which is nothing more than an apparatus by which the inflammable air, upon exploding in its interior, cannot pass out without being so far cooled, as to deprive it of the power of communicating inflammation to the surrounding atmosphere. The principle having been once discovered, it was easy to adopt and multiply practical applications of it.

From the result of these researches, it became at once evident, that to light mines infested with fire-damp, with perfect security, it was only necessary to use an air-tight lantern, supplied with air from tubes of small diameter, through which explosions cannot pass, and with a chimney, on a similar principle, at the upper part, to carry off the foul air. A common lantern, to be adapted to the purpose, merely required to be made air-tight in the door and sides, and to be furnished with the chimney, and the system of safety apertures below and above the flame of the lamp. Such, in fact, was Davy's first Safety-

* The apertures in the gauze should not be more than one-twentieth of an inch square. As the fire-damp is not inflamed by ignited wire, the thickness of the wire is not of importance; but wire from one-fortieth to one-sixtieth of an inch in diameter is the most convenient.

lamp ; and having afterwards varied the arrangement of the tubes in different ways, he at length exchanged them for canals, which consisted of close concentric hollow metallic cylinders of different diameter, so placed together as to form circular canals of the diameter of from one-twenty-fifth to one-fortieth of an inch ; and of an inch and seven-tenths in length ; by which air is admitted in much larger quantities than by the small tubes, and they are moreover much superior to the latter in practical application. He also found, that longitudinal air-canals of metal might be employed with the same security as circular canals ; and that a few pieces of tin plate, soldered together with wires to regulate the diameter of the canal, answered the purpose of the feeder or safe chimney, as well as drawn cylinders of brass.

The subjoined explanatory sketches will assist in rendering the scheme intelligible, and obviate the possibility of any misconception of the subject.

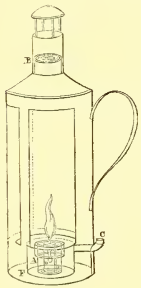


Fig. 1. represents the first Safe lantern, with its air feeder and chimney furnished with safety metallic canals. The sides are of horn or glass, made air-tight by putty or cement. A. is the lamp through which the circular air-feeding canals pass. B. is the chimney containing four such canals: above it is a hollow cylinder, with a cap to prevent dust from passing into the chimney. C. is the hole for admitting oil. F. is the rim round the bottom of the lantern, to enable it to bear motion.

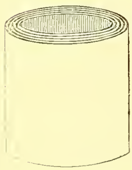


Fig. 2. exhibits an enlarged view of the safety concentric canals, which, if one-twenty-fifth of an inch in diameter, must not be less than two inches in exterior circumference, and one-seventh of an inch high.

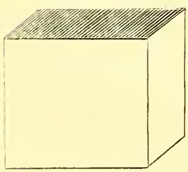


Fig. 3. exhibits the longitudinal safety canals.

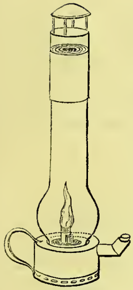


Fig. 4. represents a Safety-lamp having a glass chimney covered with tin-plate, and the safety apertures in a cylinder with a covering above: the lower part is the same as in the lantern.

Fig. 5. A glass tube furnished with *flame sieves*, in which a common candle may be burnt. A A. the flame sieves. B. a little plate of metal to prevent the upper flame sieve from being acted on by the current of hot air.

During the short visit of Sir Humphry Davy at Bishop Wearmouth, he saw the lamp which Dr. Clanny was then engaged in perfecting. It has been already observed, that it was secured against the effects of fire-damp by being supplied with atmospheric air previously conveyed through water.* The machinery of this lamp was far too cumbrous to be of general use; but its inventor was justly commended by Davy for his ingenuity and perseverance. It unfortunately happened that, in consequence of some erroneous representations made to Dr. Clanny, he received the impression that Sir Humphry had not been disposed to treat his invention with sufficient respect, nor had given him the credit to which he was so justly entitled. This suspicion, which had been long industriously kept alive, was however ultimately removed.

* M. de Humboldt conceived and executed the plan of a lamp in 1796, for giving a safe light in mines, upon a similar principle of entire insulation from the air.—*Journal des Mines*, t. viii. p. 839.

The following letter refers to this unfortunate circumstance. I have adverted to it in these memoirs, for the purpose of showing what an unfair spirit of rivalry, and what a succession of petty jealousies were excited by those generous and disinterested labours of Davy, which ought to have called forth nothing but the most lively expressions of gratitude. for his services, and admiration of his genius.

TO THE REVEREND DR. GRAY.

MY DEAR SIR, 23, Grosvenor Street, December 13.

A FRIEND of mine has sent me a newspaper—the Tyne Mercury, containing a very foolish libel upon me. It states, amongst other things, that I did not mention Dr. Clanny, or his lamp, in my late paper read before the Royal Society; whereas I mentioned his lamp as a very ingenious contrivance, and named him amongst the gentlemen who obligingly furnished me with information upon the subject.

It will be needless for me to point out to you that my lamp has no one principle in common with that of Dr. Clanny. He forces in his air through water by bellows. In mine, the air passes through safety canals without any mechanical assistance. Mine is a common lantern made close, and furnished with safety canals.

I hope I shall not hear that Dr. Clanny has in any way authorized or promoted so improper a statement as that in the Tyne Mercury; indeed, I do not think it possible.

I have at last obtained a complete model of my lamp, after many disappointments from the instrument-maker. I hope in a few days to send you a *Safe lantern*, as portable as a common made one, and the perfect security of which is demonstrable. I am, my dear Sir, your sincerely obliged,

H. DAVY.

TO THE SAME.

MY DEAR SIR, Grosvenor Street, December 15.

I SHALL inclose the first sheet of my paper, and shall be glad to preface it by some observations when you reprint it.

I shall forward my lanterns and lamps to you in a few days. They are *absolutely* safe; and if the miners have any more explosions from their light, it will be their own fault.

You will find, when you see my construction, that the principles as well as the execution are entirely new.

You will find in the second sheet of my paper, which I hope to be able to send to-morrow, the *principles* of *security*, and its limits unfolded.

I am, my dear Sir, very sincerely yours, H. Davy.

TO THE SAME.

MY DEAR SIR, London, January 1, 1816.

I fear you will have accused me of procrastination in delaying to send you my papers and my lamps.

The papers read to the Royal Society have been printed; but during the period that has elapsed since I last wrote to you, I have made a discovery much more important than those which I have already had the honour of communicating to you.

I have made very simple and economical lanterns, and candle guards, which are not only *absolutely safe*, but which give light by means of the fire-damp, and which, while they disarm this destructive agent, make it useful to the miner.

This discovery is a consequence of that which I communicated to you in my last letter on the wire sieves. I hope to be able to send you on Wednesday the printed account of my results, together with models of lamps which will burn and consume all explosive mixtures of the fire-damp.

I have at last finished my enquiries with perfect satisfaction to myself, and I feel highly obliged to you for having called my attention to a subject where my labours will I hope be of some use.

I am, my dear Sir, very sincerely yours, H. Davy.

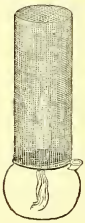
It is impossible to approach the consideration of this last, the most signal and splendid of his triumphs, without feelings of the highest satisfaction. He had already, as we have seen, disarmed the fire-damp of its terrors, it only remained for him to enlist it into his service. The simple means by which this was effected are as interesting as their results are important.*

Davy had previously arrived at the fact, that wire-gauze might be substi-

* "An Account of an Invention for giving Light in explosive mixtures of Fire-damp in Coal Mines, by consuming the Fire-damp." Read before the R.S. Jan. 11, 1816.

tuted, as air-feeders to the lamp, in the place of his tubes or safety canals; but not until after the lapse of several weeks, did the happy idea of constructing the lamp entirely of wire-gauze occur to him:—the history of this elaborate enquiry affords a striking proof of the inability of the human mind to apprehend simplicities, without a process of complication which works as the grappling machinery of truth.

His original lamp with tubes or canals, as already described, was perfectly safe in the most explosive atmosphere, but its light was necessarily extinguished by it; whereas in the wire-gauze cage, the fire damp itself continues to burn, and thus to afford to the miner a useful light, while he is equally secured from the fatal effects of explosion.

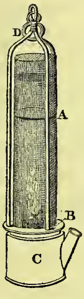


All then required for his guidance and protection in the darkness of the mine, are candles or lamps surrounded by small wire cages, which will at once supply air to the flame, and light to the miner; they may be obtained for a few pence, and be variously modified as circumstances may render necessary.

The reader is here presented with a sketch of the gauze instrument, in its first and simplest form. The original lamp is preserved in the laboratory of the Royal Institution.

Nothing now remained, but to ascertain the degree of fineness which the wire-gauze ought to possess, in order to form a secure barrier against the passage of flame. For this purpose, Davy placed his lighted lamps in a glass receiver, through which there was a current of atmospherical air, and by means of a gasometer filled with coal gas, he made the current of air which passed into the lamp more or less explosive, and caused it to change rapidly or slowly at pleasure, so as to produce all possible varieties of inflammable and explosive mixtures; and he found that iron wire-gauze composed of wires from one-fortieth to one-sixtieth of an inch in diameter, and containing twenty-eight wires, or seven hundred and eighty-four apertures to the inch, was safe under all circumstances in atmospheres of this kind; and he consequently employed that material in guarding lamps for the coal mines, where, in January 1816, they were immediately adopted, and have long been in general use.

Observations upon them in their working state, and upon the circumstances to which they are exposed, have led to a few improvements or alterations, merely connected with the modes of increasing light or diminishing heat, which were obvious from the original construction.



The annexed woodcut represents the lamp which is in present use. A is a cylinder of wire gauze, with a double top, securely and carefully fastened, by doubling over, to the brass rim B, which screws on to the lamp C. The whole is protected by strong iron supports D, to which a ring is affixed for the convenience of carrying it.

In a paper read before the Royal Society, on the 23rd of January 1817, entitled, "Some new Experiments and Observations on the Combustion of Gaseous Mixtures, with an Account of a method of preserving a continued Light in mixtures of inflammable Gases and Air without Flame," Sir H. Davy announces the application of a principle which he had discovered in the progress of his researches, for increasing the utility of the Safety-lamp, and which, a century ago, would have unquestionably exposed its author to the charge of witchcraft.

Having ascertained that the temperature of flame is infinitely higher than that necessary for the ignition of solid bodies, it appeared to him probable that, in certain combinations of gaseous bodies, although the increase of temperature might not be sufficient to render the gaseous matters themselves luminous, they might nevertheless be adequate to ignite solid matters exposed to them. During his experiments on this subject, he was led to the discovery of the curious phenomenon of slow combustion without flame. He observes, that there cannot be a better mode of illustrating the fact, than by an experiment on the vapour of ether or of alcohol. Let a few coils of wire of platinum of the one-sixtieth or one-seventieth of an inch be heated by a hot poker or candle, and let it be brought into the glass; it will presently become glowing, almost white hot, and will continue so, as long as a sufficient quantity of vapour and of air remain in the glass.*

This experiment on the slow combustion of ether is accompanied with

* This principle has been applied for constructing what has been termed the *Aphlogistic Lamp*, which is formed by placing a small coil of platinum wire round the wick of a common spirit lamp. When the lamp, after being lighted for a few moments, is blown out, the platinum wire continues to glow for several hours, as long as there is a supply of spirit of wine, and to give light enough to read by; and sometimes the heat produced is sufficient to re-kindle the lamp spontaneously. The same phenomena are produced by the vapour of camphor; and an aromatic fumigating lamp has lately been advertised for sale, which is no other than the contrivance above described; and it is evident that, if the spirit be impregnated with fragrant principles, an aromatic vinegar will be developed during its slow combustion, and diffused in fumes through the apartment.

the formation of a peculiar acrid and volatile substance possessed of acid properties, which has been particularly examined by Mr. Daniell, who, having at first regarded it as a new acid, proposed for it the name of *Lampic* acid, in allusion to the researches which led to its discovery; he has, however, since ascertained that its acidity is owing to the acetic acid, which is combined with some compound of carbon and hydrogen, different both from ether and alcohol.

The phenomena of slow combustion, as exhibited in certain states of the mine, by the Safety-lamp, are highly curious and interesting.

By suspending some coils of fine wire of platinum* above the wick of his lamp, the miner will be supplied with light in mixtures of fire-damp no longer explosive; for should his flame be extinguished by the quantity of fire-damp, the little coil of platinum will begin to glow with a light sufficiently bright to guide him in what would otherwise be impenetrable darkness, and to lead him into a purer atmosphere, when the heat thus increased will very frequently be sufficient to rekindle his lamp!

In this case it will be readily perceived, that the combustion of the fire-damp is continued so slowly and at so low a temperature, as not to be adequate to that ignition of gaseous matter which constitutes flame, although it excites a temperature sufficient to render platinum wire luminous.

Sir Humphry Davy observes, that there never can be any danger with respect to respiration, whenever the wire continues ignited; for even this phenomenon ceases when the foul air forms about two-fifths of the volume of the atmosphere.

The experiment, as originally performed by the illustrious chemist, is so interesting and instructive, that I shall here relate it in his own words.

"I introduced into a wire-gauze Safe-lamp a small cage made of fine wire of platinum of one-seventieth of an inch in thickness, and fixed it by means of a thick wire of the same metal about two inches above the wick which was lighted. I placed the whole apparatus in a large receiver, in which, by means of a gas-holder, the air could be contaminated to any extent with coal gas. As soon as there was a slight admixture of coal gas, the platinum became ignited; the ignition continued to increase till the flame of the

* Sir Humphry Davy attempted to produce the phenomena with various other metals, but he only succeeded with platinum and palladium; these bodies have low conducting powers, and small capacities for heat, in comparison with other metals, which seem to be the causes of their producing, continuing, and rendering sensible, these slow combustions.

wick was extinguished, and till the whole cylinder became filled with flame; it then diminished. When the quantity of coal gas was increased, so as to extinguish the flame, at the moment of the extinction the cage of platinum became white hot, and presented a most brilliant light. By increasing the quantity of the coal gas still farther, the ignition of the platinum became less vivid: when its light was barely sensible, small quantities of air were admitted; its heat speedily increased; and by regulating the admission of coal gas and air, it again became white hot, and soon after lighted the flame in the cylinder, which as usual, by the addition of more atmospherical air, rekindled the flame of the wick."

I have thus related, somewhat in detail, the history of a discovery, which, whether considered in relation to its scientific importance, or to its great practical value, must be regarded as one of the most splendid triumphs of human genius. It was the fruit of elaborate experiment and close induction; chance, or accident, which comes in for so large a share of the credit of human invention, has no claims to prefer upon this occasion; step by step, may he be followed throughout the whole progress of his research, and so obviously does the discovery of each new fact spring from those that preceded it, that we never for a moment lose sight of our philosopher, but keep pace with him during the whole of his curious enquiry.

He commenced, as we have seen, with ascertaining the degree of combustibility of the fire-damp, and the limits in which the proportions of atmospheric air and carburetted hydrogen can be combined, so as to afford an explosive mixture. He was then led to examine the effects of the admixture of azote and carbonic acid gas; and the result of those experiments furnished him with the basis of his first plan of security. His next step was to enquire whether explosions of gas would pass through tubes; and on finding that this did not happen, if the tubes were of certain lengths and diameters, he proceeded to examine the limits of such conditions, and by shortening the tubes, diminishing their diameters, and multiplying their number, he at length arrived at the conclusion, that a simple tissue of wire-gauze afforded all the means of perfect security; and he constructed a lamp, which has been truly declared to be as marvellous in its operation, as the storied lamp of Aladdin, realizing its fabled powers of conducting in safety, through "fiends of combustion," to the hidden treasures of the earth. We behold a power which, in its effects, seemed to emulate the violence of the volcano and the earthquake, at once restrained by an almost invisible and impalpable barrier of net-work—we behold, as it were, the dæmon of fire taken captive by Science, and ministering to the convenience of the miner, while harmlessly fluttering in an iron cage.

And yet, wonderful as the phenomenon may appear, his experiments and reasonings have demonstrated, that the interruption of flame by solid tissues permeable to light and air, depends upon no recondite or mysterious cause, but simply upon their cooling powers, which must always be proportional to the smallness of the mesh, and the mass of the metal.

When it is remembered that the security thus conferred upon the labouring community is not merely the privilege of the age in which the discovery was effected, but must be extended to future times, and continue to preserve human life as long as coal is dug from our mines, can there be found in the whole compass of art or science, an invention more useful and glorious?

The wire-gauze lamp has now been several years extensively used in the mines, and the most satisfactory and unequivocal testimonies have been published of the complete security which it affords. They have amongst the miners obtained the name of *Davys;* and such is the confidence of the workmen in their efficacy, that by their aid they enter the most explosive atmospheres, and explore the most remote caverns, without the least dread of their old enemy the *fire-damp.*

Into the mines of foreign countries the Safety-lamp has been introduced with similar success; and the illustrious discoverer has been repeatedly gratified by accounts of the enthusiasm with which his invention has been adopted in various parts of Europe.*

* A pamphlet appeared at Mons, in the year 1818, on the explosions that occur in coal mines, and on the means of preventing them by Davy's Safety-lamp. It was published under the direction of the Chamber of Commerce and Manufactures of Mons, accompanied by notes, and by the results of a series of experiments that had been conducted by M. Gossart, President of the Chamber. The province of Hainault is said to be richer in coal mines than any other part of the continent of Europe, and to have no less than one hundred thousand persons employed in the working them. The same kind of dangerous accidents occurred in these mines as in those of the North of England, and various expedients had been adopted for their prevention, which, however, availed but little in obviating them. "All the precautions," observe the reporters, "which had been hitherto known or practised, had not been able to preserve the unfortunate miners from the terrible effects of explosion. It is therefore an inappreciable benefit which we confer by making known the equally simple and infallible method of preventing these accidents, which has been discovered by the celebrated Humphry Davy."

M. Gossart gives an ample and accurate detail of the properties of the explosive gas, and confirms the truth of Davy's experiments, by which the high temperature necessary for its inflamma-

Nor is the utility of this invention limited to the operations of mining. In gas manufactories, spirit warehouses,* or druggists' laboratories, and in various other situations, where the existence of an explosive atmosphere † may expose persons to danger, the Safety-lamp may be advantageouly used ; and as science proceeds in multiplying the resources of art, this instrument will no doubt be found capable of many new applications.

By the permission of the President and Council of the Royal Society, several accounts of these researches, and of the invention and use of the Safety-lamp were printed, and circulated through the coal districts.

It might have been fairly expected that, in a district which had been so continually and so awfully visited by explosions, against which no human foresight had as yet been able to provide a remedy, the disinterested services of the greatest chemist of the age would at least have been received without a dissentient voice, and that his invention of security would have escaped the common fate of all great discoveries, and been accepted with every homage of respect and gratitude; but the inventor of the Safety-lamp was doomed to encounter a bitter hostility from persons whom a spirit of rivalry, or a feeling of hopeless emulation, had cemented into a faction.

From the period of the first announcement of the Safety-lamp, a prejudice against its use was industriously circulated amongst the miners; and some persons even maintained the monstrous proposition, that any protection against the explosions of fire-damp would injure more than it could serve

tion, and the consquent means of preventing it, by reducing that temperature, as effected during its passage through wire-gauze, are clearly demonstrated.

The lamp appears from this report to have been as useful in the mines of Flanders as in those of England. The Pamphlet is a valuable document, inasmuch as it affords an independent proof of the security of the instrument, and displays the high sense of obligation which foreign nations entertain to Sir Humphry Davy for his invention.

* The danger of carrying a naked light into an atmosphere impregnated with the fumes of spirit was awfully exemplified by the loss of the Kent East Indiaman, by fire in the Bay of Biscay, on the 1st of March 1825.

† In cases where there is any suspicion of accumulations of carburetted hydrogen from the leakage of gas pipes, or from other sources, the safety-lamp should always be employed. A terrible accident occurred some years since at Woolwich, from a room filled with the vapour of coal tar, for the purpose of drying and seasoning timber intended for ship-building. As the combustion arose from the flame issuing through the flue, which ran along the apartment, at the moment the damper was applied at the top of the building, it is evident that, had a wire-gauze guard been used, the accident could not have occurred. The house was completely demolished, and nine persons were unfortunately killed.

the collier, by inducing him to resume abandoned works, and thus continually to inhale a noxious atmosphere.

The utility of the lamp having been established, in spite of every opposition, the claims of Sir H. Davy to its invention were next publicly challenged.

It will hereafter be scarcely believed that an invention so eminently philosophic, and which could never have been derived but from the sterling treasury of science, should have been claimed in behalf of an engine-wright of Killingworth, of the name of Stephenson—a person not even professing a knowledge of the elements of chemistry. As the controversy to which this claim gave birth has long since subsided, I would willingly have treated it as a passing cloud, had not its shadow remained. The circumstances, however, of the transaction stand recorded in the Magazines of the day, and the biographer of Davy would compromise his rights, by omitting to notice the attempts that have been made to invalidate them.

The claims which were made for the priority of Mr. Stephenson's invention of the Safety-lamp were urged in several communications in the Newcastle Courant. It has been said, in reply, that if dates were taken as evidence, not merely of priority, but of originality, of invention, it must follow that Mr. Stephenson's lamp was derived from that of Sir H. Davy. With regard to the first of Stephenson's lamps, the only one upon which the shadow even of a claim can be founded, it is unnecessary for the friends of truth to adopt such a line of defence; indeed, after a deliberate examination of all that has been published on the subject, I am very willing to believe that Mr. Stephenson did construct the lamp which dates its origin from the 21st of October 1815, without any previous knowledge of the conclusions at which Davy had arrived; for it was first announced to the Coal-trade by Mr. R. Lambert on the 3rd of November, to the very meeting at which Sir H. Davy's private letter was inadvertently read.—But what were the principles, and what the construction of this lamp?

It would appear that Mr. Stephenson had entertained some vague notion of the practicability of consuming the fire-damp as fast as it entered the lamp, and that if admitted only in small quantities, it would not explode the surrounding atmosphere: for effecting this object, he constructed a lamp with an orifice, over which was placed a slide, by the movement of which the opening could be enlarged, or diminished, and the volume of fire-damp to be admitted into the lamp, regulated according to circumstances. Now such a lamp could be nothing else than an exploding lamp; for to make it burn in common air, the orifice must have been so wide that, on going into an explosive atmosphere, the combustion in the interior could not have failed to pass it, and to have exploded the mine. Here then is a *safety*-lamp, which as long as it is safe, will not burn, and the moment it begins to burn, it becomes unsafe!

The testimonies in favour of the security afforded by this lamp were evidently procured from persons who were not only ignorant of the principles of its construction, but of the methods to be pursued for ascertaining its safety. I am surely justified in such a statement, when, instead of an *explosive mixture*, I find them throwing in *pure fire-damp*, which will always extinguish flame, whether burning in a safe or unsafe lamp.

The importance and utility of Davy's lamp having been completely established by the severest ordeals, the general gratitude of the country began more publicly to display itself, and a very strong feeling prevailed, that some tribute of respect should be paid to its inventor; in accordance with which, a deputation of the Coal-owners of the rivers Tyne and Wear, and of the ports of Hartley and Blyth, requested the honour of an interview with Sir H. Davy; upon which occasion they presented him with the following letter, containing an expression of the thanks of the Coal-owners.

TO SIR HUMPHRY DAVY, LL.D. &c.

SIR, Newcastle, March 25, 1816.

As chairman of the general meeting of proprietors of coal-mines upon the rivers Tyne and Wear, held in the Assembly-rooms at Newcastle, on the 18th instant, I was requested to express to you their united thanks and approbation for the great and important discovery of your Safety-lamp for exploring mines charged with inflammable gas, which they consider admirably calculated to obviate those dreadful calamities, and the lamentable sacrifice of human life, which of late years have so frequently occurred in the mines of this country.

They are most powerfully impressed with admiration and gratitude towards the splendid talents and brilliant acquirements that have achieved so momentous and important a discovery, unparalleled in the history of mining, and not surpassed by any discovery of the present age; and they hope that, whilst the tribute of applause and glory is showered down upon those who invent the weapons of destruction, this great and unrivalled discovery for preserving the lives of our fellow-creatures, will be rewarded by some mark of national distinction and honour. I am, Sir,

Your most obedient humble Servant,

George Waldie, Chairman.

A plan, however, was under consideration for recording the admiration and gratitude of the Coal-owners, by a more permanent and solid memorial. The nature of this proposition will be best disclosed by inserting the following letter from Mr. Buddle.

TO THE REVEREND DR. GRAY.

SIR, Wall's-End Colliery, August 27, 1816.

As I know that you feel much interest in all matters relating to Sir H. Davy's Safety-lamp, I trust you will excuse the liberty I take in informing you, that the Committee of the Tyne, approving highly of the suggestion, that some mark of acknowledgment and respect should be presented to Sir Humphry by the Coal-trade of this country, for the happy invention of his lamp, have convened a general meeting of Coal-owners, to be holden at my office in Newcastle, on Saturday next the 31st instant, at twelve o'clock, to take the subject into consideration.

I should have sooner informed you of this proposed meeting, had I not been detained in Cumberland until yesterday; but I shall have the pleasure of transmitting to you a copy of its resolutions.

I am sure that you will be gratified to learn that the lamps continue to go on as well as possible. We now have twelve dozen of them in daily use at this place. I have the pleasure to remain, with the greatest respect, Sir,

Your most obedient humble Servant,

John Buddle.

TO THE SAME.

SIR, Newcastle, September 7, 1816.

I now have the pleasure of sending you a copy of the Resolutions of the general meeting of Coal-owners on the 31st instant, and shall take the liberty of informing you of the future progress of this affair.

Sir Humphry did me the honour yesterday to accompany me through the workings of a coal-pit at Wall's-End, when I had an opportunity of witnessing several interesting experiments on his Safety-lamp; and I have the satisfaction to add, that I believe he has now advanced it to the highest degree of perfection. I am, respectfully, Sir,

Your humble Servant,

JOHN BUDDLE.

The satisfactory result of this visit Sir Humphry communicated to Mr. Lambton, now Lord Durham; and I shall take this opportunity to state, that for this as well as for several other letters I shall hereafter have occasion to introduce, I am indebted to that noble Lord, through the kind application of my friend, Sir Cuthbert Sharp.

TO J. G. LAMBTON, ESQ. M. P.

MY DEAR SIR, Newcastle, September 9, 1816.

SINCE I last had the pleasure of seeing you, I have examined the workings in the Wall's-End collieries by the lamps, and have tried them in various explosive mixtures.

On Sunday, I went with Mr. Buddle to your *blower*, with the single lamps furnished with small tin reflectors. This simple modification rendered them perfectly safe, even in the furious *blow-pipe*, and at the same time increased their light. Nothing could be more satisfactory than all the trials.

I have left a paper in the hands of the Rev. J. Hodgson, which will be printed in a day or two; and I have desired him to send you ten copies, or as many more as you may like to have.

I trust I have now left nothing undone as to the perfect security of the lamps, under every possible circumstance.

I feel highly gratified that it was at your mines I effected the only object that remained to be accomplished—that of guarding against *blowers* meeting fresh currents of air.

I thank you very sincerely for the interest you have taken in the lamps, connected with my efforts to render them applicable in all cases.

I remain, &c.

H. DAVY.

On the 19th of October 1816, a letter appeared in the Durham County Advertiser, dated "Gosforth, August 22nd, 1816," in the name of Mr. W. Brandling, in which, alluding to the Resolutions of the Coal-owners of the 31st of August, he expresses a wish that a strict examination should take place previous to the adoption of a measure which might convey a decided opinion to the public, as to the person to whom the invaluable discovery of the Safety-lamp is actually due. "The conviction," says he, "upon my mind is, that Mr. George Stephenson, of Killingworth Colliery, is the person who first discovered and applied the principle upon which safe lamps may be constructed; for, whether the hydrogen gas is admitted through capillary tubes, or through the apertures of wire-gauze, which may be considered as merely the orifices of capillary tubes, does not, as I conceive, in the least affect the principle.

"In the communications I have seen from Sir H. Davy, no dates are mentioned; and it is by a reference to them only that the question can be fairly decided. For the information of the Meeting, therefore, I shall take the liberty of enclosing some which I received from Mr. Stephenson, to the correctness of which, as far as I am concerned, I can bear testimony; at the same time I beg leave to add, that the principle of admitting hydrogen gas in such small detached portions that it would be consumed by combustion,* was, I understand, stated by him to several gentlemen, as the idea he had embraced two months before his lamp was originally constructed."

Mr. Brandling then proceeds to state, that the Killingworth lamp, with a tube to admit the air, and a slide at the bottom of such tube to regulate the quantity to be admitted, was first tried in the Killingworth pits on Saturday October the 21st, 1815; but not being found to burn well, another was ordered the same day with three capillary tubes to admit the air; and on being tried in the mine on the 4th of November following, was found to burn better and to be perfectly *safe*.† On the 17th of November, it was *tried*‡ at Killingworth office with inflammable air before Richard Lambert, Esq.; and on the 24th of the same month, before C. J. Brandling, Esq. and Mr. Murray.

"On the 30th of November," he says, "a lamp was tried in the mine, in

* Granted:—but what connexion has that with the principle of Davy's lamp, or with any *Safety* lamp?

† It could not have been safe.

‡ "Tried"—but how was it tried?—by forcing in *pure* fire-damp, which will extinguish any lamp, instead of exposing the flame to an explosive mixture, which could alone furnish any test of its security.

which the air was admitted by means of a double row of small perforations, and found to be perfectly safe, and to burn extremely well."*

At an adjourned Meeting of the Coal-owners, held on the 11th of October 1816, J. G. Lambton, Esq. M.P. in the chair; Mr. William Brandling moved —"That the Meeting do adjourn, until, by a comparison of dates, it shall be ascertained whether the merit of the Safety-lamp belongs to Sir Humphry Davy or to Mr. George Stephenson."

On the question being put thereon, THE SAME PASSED IN THE NEGATIVE.

A great number of the Coal-owners, instead of pursuing the idea which had at first been suggested, of a general contribution on the vend, immediately commenced a subscription of individual proprietors of coal-mines; a measure which, it was thought, would express more distinctly and unequivocally the opinion of the trade as to the merit of the invention. The plan is developed in the following letter.

TO THE REVEREND DR. GRAY.

SIR, Wall's-End Colliery, October 27, 1816.

It is the anxious wish of almost every individual in the trade to compliment Sir Humphry Davy, in that way which may be most grateful to his feelings.

It has been suggested that the object will be best attained by substituting an individual (colliery) subscription, instead of the proposed contribution on the vend; and it will at the same time show more distinctly the real opinion of the trade as to the merit of the invention.

This idea was not suggested till yesterday afternoon, and of course there has been but little time to communicate it to the several Coal-owners; but *all* who have heard of the plan approve of it.

To facilitate the business, the committee have formed the annexed scale of contribution.†

* * * * * * *

I trust, Sir, you will excuse the trouble which I have given you on this subject; but I am aware that you must feel interested in it; and I hope, Sir, you will allow me to add, that I am fully sensible of the obligation which the Coal trade is under to yourself, for having drawn Sir H. Davy's attention to

* Very likely: but the reader will please to recollect, that Sir H. Davy had, before this, published an account of his principle of safety by systems of tubes or canals.

† I have not thought it necessary to enumerate the various sums which the different mines were called upon to contribute.

that particular line of investigation, which has led to the important discovery of the Safety-lamp. I am, Sir, with the greatest respect, your most obedient humble servant, JOHN BUDDLE.

Some slight alterations were afterwards made in this scheme; in consequence of a wish having been expressed that the Bishop of Durham and the Duke of Northumberland should take the lead in a subscription. The following letter conveys some further information upon this subject.

TO THE REVEREND DR. GRAY.

SIR, Newcastle, January 11, 1817.

I HAVE to acknowledge the receipt of your letter of the 9th instant, communicating the intention of the Reverend the Dean and Chapter of Durham, to subscribe fifty guineas towards the plate to be presented to Sir H. Davy, which, together with two hundred guineas from the Coal-owners of the Wear, makes the subscription amount to nearly £1500, and I shall expect some further subscriptions.

I am sure it will afford you satisfaction to learn that the lamps still continue to give the most gratifying proofs of the advantages resulting from their invention, and that not a single inch of human skin has been lost by fire, wherever they have been used.

Sir Humphry has just made another important improvement in the lamp, by constructing the cylinder of *twisted* wire-gauze. Lamps thus constructed, possess the singular property of not becoming red hot, under any circumstances of exposure to explosive mixtures, whether urged by a blast, or in a state of rest. I am with great respect, Sir, your most obedient humble servant,

JOHN BUDDLE.

It may be collected from the following letter, that the Committee, in announcing to Sir H. Davy the intended present of plate, delicately sounded him as to the form in which it would be most agreeable to him.

TO N. CLAYTON, ESQ.

SIR, Grosvenor Street, March 23, 1817.

ON my return to town, after an absence of some days, I found the letter of March the 13th, with which you honoured me, at the Royal Institution. I shall not lose a moment in replying to it, and in expressing my grateful feelings for the very flattering communication it contains.

The gentlemen interested in the coal-mines of the two rivers Tyne and Wear, cannot offer me any testimony of their kindness, which I shall not receive with infinite pleasure.

I hardly know how to explain myself on the particular subject of your letter; but as the Committee express themselves satisfied as to the utility of the Safety-lamp, I can only desire that their present, as it is highly honourable to me, should be likewise useful to my friends, and a small social circle, which it would be as a dinner-service for ten or twelve persons.

I wish that even the plate from which I eat should awaken my remembrance of their liberality, and put me in mind of an event which marks one of the happiest periods of my life.

I cannot find any language sufficiently strong to express my thanks to the gentlemen for the manner in which they have distinguished my exertions in their cause, and in the cause of humanity. I have the honour to remain, &c.

H. Davy.

To revert once again to the faction—for such I must denominate it—which, in opposition to the most unequivocal evidence, continued to support the unjust claims of Mr. Stephenson; it would appear from various letters in my possession, that the feelings of Davy were greatly exasperated by this ungenerous conduct.

I shall introduce one of these letters, playful in the midst of its wrath, addressed to Mr. Lambton, the friend* of his youth, and the manly and kind supporter of his scientific character, in the hour of persecution.

TO J. G. LAMBTON, ESQ. M. P.

MY DEAR SIR, Queen Square, Bath, October 29, 1816.

The severe indisposition of my wife has altered my plans. Your letter slowly followed me here.

Mr. ——— is one of the persons who, after I had advanced a principle of security for a lamp, came upon the ground to endeavour to jocky me. I was not looking to a prize, I merely came forward to show an animal, the

* It will be remembered that they resided together in the house of Dr. Beddoes. See page 42 of these memoirs. In the library at Lambton, there is a good portrait of Sir H.

breed of which might be useful, when Mr. ——, Dr. ——, &c. brought their sorry jades, which had never before been seen or heard of, to kick at my blood mare.

I never heard a word of George Stephenson and his lamps till six weeks after my principle of security had been published; and the general impression of the scientific men in London, which is confirmed by what I heard at Newcastle, is, that Stephenson had some loose idea floating in his mind, which he had unsuccessfully attempted to put in practice till after my labours were made known;—then, he made something like a safe-lamp, except that it is not *safe*, for the apertures below are four times, and those above, twenty times too large; but, even if Stephenson's plans had not been posterior to my principles, still there is no analogy between his glass exploding machine, and my metallic tissue, permeable to light and air, and impermeable to flame.

I am very glad that you attended the meeting; your conduct at no very distant period will be contrasted with that of some great coal-proprietors, who find reasons for their indifference, as to a benefit conferred upon them, in insinuations respecting the claims of Dr. Clanny, Mr. Stephenson, and others.

Where men resolve to be ungrateful, it is natural that they should be illiberal; and illiberality often hardens into malignity.

I shall receive any present of plate under your auspices, and those of the Committee over which you preside, with peculiar satisfaction. It will prove to me that my labours have not been disregarded by men, of whose good opinion I am proud.

I hope you will not blame me for not taking any notice of the attacks of my enemies in the North. I have no desire to go out of my way to crush gnats that buzz at a distance, and do not bite me, or to quarrel with persons who shoot arrows at the moon, and believe, because they have for an instant intercepted a portion of her light, that they have hit their mark. I am sensible to the circumstances under which you attended the meeting.

I offer you my sincere congratulations, and ardent wishes that you may enjoy all possible happiness.

Believe me, &c.

H. Davy.

On the 13th of September 1817, Sir Humphry Davy being expected to pass through Newcastle on his return from Scotland, preparations were made, and notice given of a dinner which it was proposed should take place on the

25th instant, for the purpose of presenting to the illustrious philosopher the service of plate which had been prepared for his acceptance.

Upon this gratifying occasion, a very large party assembled at the Queen's Head, consisting of a numerous and respectable body of Coal-owners, and such other gentlemen as had interested themselves during the progress of the investigation, or taken an active part in promoting the introduction of the lamp into the mines.

After the dinner had concluded, and certain toasts of form had been drunk, Mr. Lambton, who filled the chair on the occasion, rose, and on presenting the service of plate to the illustrious guest, addressed him, in a tone of great animation and feeling, in nearly the following terms:

" Sir Humphry, — It now becomes my duty to fulfil the object of the meeting, in presenting to you this service of plate, from the Coal-owners of the Tyne and Wear, as a testimony of their gratitude for the services you have rendered to them and to humanity.

" Your brilliant genius, which has been so long employed in an unparalleled manner, in extending the boundaries of chemical knowledge, never accomplished a higher object, nor obtained a nobler triumph.

" You had to contend with an element of destruction which seemed uncontrollable by human power; which not only rendered the property of the coal-owner insecure, but kept him in perpetual alarm for the safety of the intrepid miner in his service, and often exhibited to him the most appalling scenes of death, and heart-sickening misery.

" You have increased the value of an important branch of productive industry; and, what is of infinitely greater importance, you have contributed to the lives and persons of multitudes of your fellow-creatures.

" It is now nearly two years that your Safety-lamp has been used by hundreds of miners in the most dangerous recesses of the earth, and under the most trying circumstances. Not a single failure has occurred—its absolute security is demonstrated. I have, indeed, deeply to lament more than one catastrophe, produced by fool-hardiness and ignorance, in neglecting to use the safeguard you have supplied; but these dreadful accidents even, if possible, exalt its importance.

" If your fame had needed any thing to make it immortal, this discovery alone would have carried it down to future ages, and connected it with benefits and blessings.

" Receive, Sir Humphry, this permanent memorial of our profound respect and high admiration—a testimony, we trust, equally honourable to you and to us. We hope you will have as much pleasure in receiving, as we feel in offering it;—long may you live to use it—long may you live to pursue your splendid career of scientific discovery, and to give new claims to the gratitude and praise of the world."

Sir Humphry having received the plate, replied as follows:

"Gentlemen,—I feel it impossible to reply, in an appropriate manner, to the very eloquent and flattering address of your distinguished Chairman. Eloquence, or even accuracy of language, is incompatible with strong feeling; and on an occasion like the present, you will give me credit for no small degree of emotion.

"I have been informed that my labours have been useful to an important branch of human industry connected with our arts, our manufactures, commerce, and national wealth. To learn this from such practical authority is the highest gratification to a person whose ardent desire has always been to apply science to purposes of utility.

"It has been also stated, that the invention which you are this day so highly honouring, has been subservient to the preservation of the lives and persons of a most useful and laborious class of men: this, coming from your own knowledge, founded upon such ample experience, affords me a pleasure still more exalted—for the highest ambition of my life has been to deserve the name of a friend to humanity.

"To crown all, you have, as it were, embodied these sentiments in a permanent and magnificent memorial of your good opinion. I can make only imperfect and inadequate efforts to thank you.

"Under all circumstances of my future life, the recollection of this day will warm my heart; and this noble expression of your kindness will awaken my gratitude to the latest moment of my existence."

Sir Humphry having sat down, and the cheering of the company subsided, the Chairman proposed the health of the illustrious Chemist, in three times three.

"Gentlemen," said Sir Humphry, "I am overpowered by these reiterated proofs of your approbation. You have overrated my merits. My success in your cause must be attributed to my having followed the path of experiment and induction discovered by philosophers who have preceded me: willingly would I divide your plaudits with other men of science, and claim much for the general glory of scientific discovery in a long course of ages.

" Gentlemen, I might dwell at some length upon the great increase of wealth and power to the country, within the last half century, by scientific invention, which never could have existed without coal mines:—I shall refer only to the improvement in the potteries, to the steam-engine, and to the discovery of the gas lights.

" What an immense impulse has the steam-engine given to the arts and manufactures! How much has it diminished labour, and increased the real strength of the country, far beyond a mere increase of population! By giving facilities to a number of other inventions, it has produced even a moral effect in rendering capital necessary for the perfection of labour, credit essential to capital, and ingenuity and mental energy a secure and dignified species of property.

" Science, Gentlemen, is of infinitely more importance to a state than may at first sight appear possible; for no source of wealth and power can be entirely independent of it; and no class of men are so well able to appreciate its advantages as that to which I am now addressing myself. You have not only derived from it the means of raising your subterraneous wealth, but those also of rendering it available to the public.

" Science alone has made pit-coal such an instrument in the hands of the chemist and mechanic; it has made the elements of fire and water perform operations which formerly demanded human labour, and it has converted the productions of the earth into a thousand new forms of use and beauty.

" Gentlemen, allow me to observe, in conclusion, that it was in pursuing those methods of analogy and experiment, by which mystery had become science, that I was fortunately led to the invention of the Safety-lamp. The whole progress of my researches has been registered in the Transactions of the Royal Society, in papers which that illustrious body has honoured by their biennial medal;* in which I can conscientiously assert, that I have gratefully acknowledged even the slightest hints or offers of assistance which I have received during their composition.

" I state this, Gentlemen, not from vain-glory, but on account of certain calumnious insinuations which have arisen—not in the scientific world, for to that the whole progress of my researches is well known, but in a colliery. I must ever treat these insinuations with contempt; and after the honest indignation which has been expressed against them by the Coal-owners in general, I cannot feel any anxiety on the subject, nor should I have referred to it at

* The Rumford Medal, to be hereafter noticed.

all, did I not believe that the very persons amongst whom these insinuations originated, were extensively benefited by, and were constantly using the invention they would seek to disparage. I could never have expected that such persons would have engaged their respectable connexions in mean attempts to impeach the originality of a discovery, given to them in the most disinterested manner, and for which no return was required but an honest acknowledgment of the benefit, founded upon truth and justice.

"I do not envy them their feelings, particularly at the present moment: I do not wish to enquire into their motives: I do hope, however, that their conduct has been prompted by ignorance rather than by malevolence, by misapprehension rather than by ingratitude.

"It was a new circumstance to me, that attempts to preserve human life, and to prevent human misery, should create hostile feelings in persons who professed to have similar objects in view.

"Gentlemen, I have had some opposition, much labour, and more anxiety, during the course of these researches; but had the opposition, the labour, and the anxiety been a thousand times as great, the events of this day would have been more than a compensation."

Sir Humphry, after drinking the health and happiness of the company, proposed as a sentiment—"Prosperity to the Coal-trade."

The healths of the Duke of Northumberland, the Bishop of Durham, and the Reverend Dr. Gray, were drunk in succession.

At ten o'clock, Sir Humphry, accompanied by the chairman, retired amidst the enthusiastic plaudits of a meeting, the object of which being one of convivial benevolence, so was its effect that of unclouded hilarity.

The party which had supported the claims of Mr. Stephenson had also their meeting; and it was held on the 1st of November. At this meeting it was resolved, that it was the opinion of the persons present, that Mr. G. Stephenson having discovered the fact, that explosions of hydrogen gas will not pass through tubes and apertures of small dimensions, and having been the first to apply the principle to the construction of a Safety-lamp, is entitled to some reward.

A committee was accordingly formed to carry this resolution into effect, at the head of which was placed the name of the Earl of Strathmore.

The respectable body of Coal-owners, under whose auspices the invention of Sir Humphry Davy had been introduced and rewarded, felt that they owed it to their own characters to repel assertions which amounted to a charge against themselves of ingratitude and injustice: a general meeting was accordingly summoned, at the Assembly Rooms in Newcastle, on the 26th of November 1817, J. G. Lambton, Esq. M. P. in the chair—when it was resolved,

"That the Resolutions passed at the Meeting of the friends of Mr. G. Stephenson on the 5th instant, impugn the justice and propriety of the proceedings of a meeting of the Coal-trade on the 31st of August 1816:

"That the present meeting therefore feel themselves called upon, as an act of justice to the character of their great and disinterested benefactor, Sir Humphry Davy, and as a proof that the Coal-trade of the North in no way sanctions the resolutions of Mr. Stephenson's friends, to state their decided conviction, that the merit of having discovered the fact, that explosions of fire-damp will not pass through tubes and apertures of small dimensions, and of having applied that principle to the construction of a Safety-lamp, *belongs to Sir Humphry Davy alone*:

"That this meeting is also decidedly of opinion, from the evidence produced in various publications by Mr. George Stephenson and his friends, subsequently to the meeting of the Coal-trade which was held on the 18th of March 1816, as well as from the documents which have been read at this meeting, that Mr. Stephenson *did not* discover the fact, that explosions of fire-damp will not pass through tubes and apertures of small dimensions; and that he *did not* apply that principle to the construction of a Safety-lamp; and that the latest lamps made by Mr. Stephenson are evident imitations of those of Sir Humphry Davy, and that, even with that advantage, they are so imperfectly constructed as to be actually unsafe:

"That the above resolutions be published thrice in the Newcastle papers, and in the Courier, Morning Chronicle, and Edinburgh Courant; and that printed copies thereof be sent to the Lords Lieutenants of the two counties, to the Lord Bishop of Durham, and to the principal owners and lessors of collieries upon the Tyne and Wear."

The following letter from Sir Humphry Davy announces the farther measures which he also had thought proper to pursue, in order to counteract the impression which the meeting of Mr. Stephenson's friends might have produced on the less informed part of the public.

TO J. G. LAMBTON, ESQ. M. P.

MY DEAR SIR, November 21, 1817.

I SHALL send off by this post a copy of the resolutions, which will appear to-morrow in the Chronicle and Courier.

The men of science who have signed these resolutions are the first chemists and natural philosophers of the country, with the President of the Royal Society, the most illustrious body in Europe, at their head.

It is disagreeable to be thus obliged to use artillery for the destruction of bats and owls; but it was necessary that something should be done.

The Messrs —— have for a long time been endeavouring to destroy my peace of mind; my offence being that of conferring a benefit.

The only persons I knew in Newcastle, before I gave the Safety-lamp to the Coal-owners, were Dr. Headlam and Mr. Bigge, so that friends I had none; and the few persons with whom I had a slight acquaintance, and who were civil to me before I discovered the Safety-lamp, became my enemies. It requires a deep metaphysician to explain this—Can it be that I did not make them the medium of communication to the colliers?—But I quit a subject to which I have no desire to return, and shall only recollect that day when your eloquence touched my feelings more than it flattered my self-love.

Believe me, &c. &c. H. Davy.

The following are the Resolutions of a Meeting adverted to in the preceding letter, and which was held "for considering the Facts relating to the Discovery of the Lamp of Safety."

Soho Square, Nov. 20, 1817.

"An advertisement having been inserted in the Newcastle Courant, of Saturday, November 7, 1817, purporting to contain the Resolutions of 'A Meeting held for the purpose of remunerating Mr. George Stephenson, for the valuable service he has rendered mankind by the invention of his Safety-lamp, which is calculated for the preservation of human life in situations of the greatest danger,'

"We have considered the evidence produced in various publications by Mr. Stephenson and his friends, in support of his claims; and having examined his lamps, and enquired into their effects in explosive mixtures, are clearly of opinion—

"First,—That Mr. George Stephenson *is not* the author of the discovery of the fact, that an explosion of inflammable gas will not pass through tubes and apertures of small dimensions.

"Secondly,—That Mr. George Stephenson *was not* the first to apply that principle to the construction of a Safety-lamp, none of the lamps which he made in the year 1815 having been safe, and there being no evidence even of their having been made upon that principle.

"Thirdly,—That Sir Humphry Davy not only discovered, independently of all others, and without any knowledge of the unpublished experiments of the late Mr. Tennant on Flame, the principle of the non-communication of explosions through small apertures, but that he has also the sole merit of having first applied it to the very important purpose of a Safety-lamp, which has evidently been imitated in the latest lamps of Mr. George Stephenson.

(Signed) "JOSEPH BANKS, P.R.S.
"WILLIAM THOMAS BRANDE,
"CHARLES HATCHETT,
"WILLIAM HYDE WOLLASTON."

Thus terminated a controversy, the discussion of which, I am well aware, many of my readers will consider as having been protracted to a tedious, and perhaps to an unnecessary extent; but the biographer had no alternative. In passing it by without a notice, he would have violated his faith to the public, have given a tacit acknowledgment of the claims of Stephenson, and, in his judgment, have committed an act of gross injustice to the illustrious subject of his history; while by giving only an abridged statement, he would have furnished a pretext for doubt, and an opportunity for malevolence.

It is due also to Sir Humphry Davy to observe, that had he practised more reserve in the communication of his results, the spirit of rivalry would have expired without a struggle,—for it derived its only support and power from the generosity of its victim. Had he secured for himself the advantages of his invention by patent, he might have realized wealth to almost any extent; but to barter the products of his intellectual exertions for pecuniary profit, was a course wholly at variance with every feeling of Davy's mind; and we therefore find him, in the advancement, as at the commencement of his fleeting career, spurning the golden apples from his feet, and hastening to the goal for that prize which could alone reward all his labours—the meed of immortal fame.

From a letter dated Newcastle, August 1830, which I had the pleasure to receive from Mr. Buddle, I extract the following interesting passage:—

"In the autumn of 1815, Sir Humphry Davy accompanied me into some of our fiery mines, to *prove* the efficacy of his lamp. Nothing could be more gratifying than the result of those experiments, as they inspired every body with perfect confidence in the security which his invention had afforded.

"Sir Humphry was delighted, and I was overpowered with feelings of gratitude to that great genius which had produced it.

"I felt, however, that he did not contemplate any pecuniary reward; and, in a private conversation, I remonstrated with him on the subject. I said, 'You might as well have secured this invention by a patent, and received your five or ten thousand a-year from it.' The reply of this great and noble-minded man was,—'No, my good friend, I never thought of such a thing; my sole object was to serve the cause of humanity; and, if I have succeeded, I am amply rewarded in the gratifying reflection of having done so.' I expostulated, saying, that his ideas were much too philosophic and refined for the occasion. He replied, 'I have enough for all my views and purposes; more wealth might be troublesome, and distract my attention from those pursuits in which I delight; —more wealth,' he added, 'could not increase either my fame or my happiness. It might, undoubtedly, enable me to put four horses to my carriage; but what would it avail me to have it said that Sir Humphry drives his carriage and four?'"

The present Bishop of Bristol, to whom the world is so greatly indebted for having first called the attention of Sir Humphry Davy to the subject of explosions from fire-damp, and who has kindly interested himself in my arduous and anxious undertaking, was desirous to obtain for me the latest accounts with respect to the Safety-lamp, as to the constancy of its use, and the extent of its security; and his Lordship informs me that having applied to Mr. Buddle and Mr. Fenwick for information upon these points, their answers have been most satisfactory; at the same time, his Lordship transmitted me much valuable information, which was accompanied by the following letter from Mr. Buddle:—

TO THE RIGHT REVEREND THE LORD BISHOP OF BRISTOL.

MY LORD, Wall's-End, August 11, 1830.

I HAVE the honour to acknowledge the receipt of your Lordship's letter of yesterday's date. I am glad your Lordship has interested yourself in Doctor Paris's work, and I hope that he will be enabled, through the assistance of Sir Humphry's friends, to do ample justice to the genius and worth of that excellent man.

I should be very happy if any letters of mine could assist Dr. Paris in doing justice to his merits in the invention of the Safety-lamp; and I shall with pleasure submit to your Lordship's better judgment and discretion the selection of such of them as may seem to be conducive to that object.

I do not find that any improvement whatever has been made, either in the principle or construction of the *original lamp*, as presented to us by Sir Humphry. His transcendent genius seems to have anticipated every thing belonging to the subject, and has left nothing more to be done.

I have the honour to be, my Lord, with great respect,

Your Lordship's most obedient, humble servant,

JOHN BUDDLE.

In consequence of some late reports of accidents in the mines, I requested my friend Sir Cuthbert Sharp to make certain enquiries in the mining districts; and for this purpose, I sent him a string of queries, to which I begged him to obtain answers. These questions were submitted to Mr. Buddle, and they produced the following letter.

TO SIR CUTHBERT SHARP.

MY DEAR SIR CUTHBERT, Newcastle, August 28, 1830.

I RETURN Dr. Paris's letter, and shall briefly answer his enquiries.

If the Davy lamp was exclusively used, and due care taken in its management, it is certain that few accidents would occur in our coal mines; but the exclusive use of the "*Davy*" is not compatible with the working of many of our mines, in consequence of their not being workable without the aid of gunpowder.

In such mines, where every collier must necessarily fire, on the average, two *shots* a-day, we are exposed to the risk of explosion from the ignition of the gunpowder, even if no naked lights were used in carrying on the ordinary operations of the mine.

This was the case in Jarrow Colliery, at the time the late accident happened. As the use of gunpowder was indispensable, naked lights were generally used, and the accident was occasioned by a '*bag*' of inflammable air forcing out a large block of coal, in the face of a drift, from a fissure in which it had been pent up, perhaps from the Creation, and firing at the first naked light with which it came in contact, after having been diluted down to the combustible point by a due admixture of atmospheric air.

As to the number of old collieries and old workings which have been renovated, and as to the quantity of coal which has been, and will be saved to the public by the invention of the "*Davy*," it is scarcely possible to give an account, or to form an estimate.

In this part of the country, 'Walker's Colliery,' after having been completely worked out, according to the former system, with candles and steel-mills, and after having been abandoned in 1811, was re-opened in 1818 by the aid of the "*Davy*," and has been worked on an extensive scale ever since, and may continue to be worked for an almost indefinite period.

Great part of the formerly relinquished workings of Wall's-end, Willington, Percy-main, Hebburn, Jarrow, Elswick, Benwell, &c. &c., as well as several collieries on the Wear, have been recovered, and are continued in work by the invention of the "*Davy*."

If I had only, what you know perfectly well I have not—Time, I could write a volume on this subject.

I shall shortly, through the medium of a friend, get an important paper on the subject of the "*Davy*," put into Dr. Paris's hands.

Believe me, my dear Sir Cuthbert, to remain yours very faithfully,

John Buddle.

In the year 1825, Sir Humphry Davy had the honour to receive from the Emperor Alexander of Russia, a superb silver gilt vase, standing in a circular tray enriched with medallions. On the cover was a figure, of about sixteen or eighteen inches in height, representing the God of Fire weeping over his extinguished torch.

The circumstances under which this vase was presented have been communicated to me by Mr. Smirnove, Secretary to the Embassy.

TO J. A. PARIS, M. D.

DEAR SIR, Wigmore Street, May 29, 1830.

It was in the month of April, or May, 1815, that the late Sir Humphry Davy expressed to Prince, then Count, Lieven, his wish to offer to the Emperor of Russia a model of his Safety-lamp, which he had recently improved, accompanied by an explanatory pamphlet on the subject.

Prince Lieven of course complied with this request; and the Emperor having been pleased to accept it, ordered the Ambassador, in November of the same year, to thank Sir Humphry for it in his Majesty's name, and to assure him how much his Majesty appreciated the merit of an invention, the double effect of which was to favour the progress of more than one branch of industry, and to ensure the safety of persons employed in the coal-mines, against those fatal accidents which had hitherto so frequently occurred. The Ambassador, at the same time, delivered to Sir Humphry a silver-gilt Vase,* in the name of the Emperor, in testimony of the high satisfaction with which that sovereign had been pleased to accept the object in question. I beg you to believe me, with regard and esteem,

Your faithful servant,

JOHN SMIRNOVE.

It is well known to the friends of Davy, that in his conversation as well as in his correspondence, he always dwelt with peculiar satisfaction and delight upon the invention of his Safety-lamp.

Mr. Poole, in a letter lately addressed to me, observes—"How often have I heard him express the satisfaction which this discovery had given him. 'I value it,' said he, 'more than any thing I ever did. It was the result of a great deal of investigation and labour; but, if my directions be only attended to, it will save the lives of thousands of poor labourers. I was never more affected,' he added, 'than by a written address which I received from the working colliers, when I was in the North, thanking me, in behalf of themselves and their families, for the preservation of their lives.' I remember how delighted he was when he showed me the service of plate presented to him by those very men and their employers, as a testimony of their gratitude."

The following letter evinces a similar feeling.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Queen's Square, Bath, October 29, 1816.

IT is very long since any letters have passed between us. The affections and recollections of friendly intercourse are of a very adhesive nature; and I think you will not be displeased at being put in mind that there is an old friend not very far from you, who will be very glad to see you.

Bath does not suit me much, nor should I remain here, but my wife has been indisposed, and the waters seem to benefit her, and promise to render her permanent service, and if that happens, I shall be pleased even with this uninteresting city.

* Of the value of about one hundred and eighty guineas.

I have seen many countries and nations since we met.

* * * * * * *

* * * * * * *

I have just come from the North of England, where it has pleased Providence to make me an instrument for preserving the lives of some of my fellow-creatures. You, I know, are of that complexion of mind that the civic crown will please you more than even the victor's laurel wreath.

I have a bed, though a small one, at your service; if you can come here for two or three days, I assure you we shall be most happy to see you. We shall remain in Bath about three weeks. I shall be absent for a few days in the beginning of next week, and after that I shall be stationary till the middle of November. Give me a few lines, and say when we may expect you.

I am, my dear Poole, very sincerely yours, H. Davy.

TO THE SAME.

Grosvenor Street, December 3, 1817.

MY DEAR POOLE,

The late melancholy event* has thrown a gloom over London, and indeed over England. The public feeling is highly creditable to the moral tone of the people.

The loss of a Princess, known only by good qualities, living in a pure and happy state of domestic peace, is in itself affecting; but when it is recollected that two generations of sovereigns of the first people in the world have been lost at the same moment, the event becomes almost an awful one.

I go on always labouring in my vocation. I am now at work on a subject almost as interesting as the last which I undertook. It is too much to hope for the same success; at least I will deserve it.

When you come to town in the spring, which I trust you will do, I shall show you my service of plate. I do not think you will like it the less for the cause of the gift.

I am not sure whether I shall not take a run down to Nether Stowey and the west for a few days, if you encourage me with any hopes of the estate† and of woodcocks. You will fix my plans.

I shall be disengaged between the 15th and Christmas, and shall like to revisit Lymouth, and above all to shake you by the hand.

* The death of the Princess Charlotte.

† He here alludes to an estate in the neighbourhood of Nether Stowey, which he wished to purchase, and about which he had requested Mr. Poole to make enquiries.

Lady D. is in better health than I have ever known her to possess. She begs her kind remembrances.

I am, my dear Poole, most affectionately yours, H. DAVY.

In a strictly scientific point of view, the most interesting results which have arisen out of the investigation for constructing a Safety-lamp, are perhaps those which have made us better acquainted with the true nature of flame, and the circumstances by which it is modified; and which have led to some practical views connected with the useful arts.

It is, I think, impossible to enter into the details of those curious investigations* which, under the title of "Some Researches on Flame," were communicated to the Royal Society, and read before that body on the 16th of January 1817, without being forcibly struck with the address by which Davy, in the first instance, brought abstract science to promote and extend practical knowledge; and then, as it were by a species of multiplied reflection, applied the new facts thus elicited for the farther extension of speculative truth; which in its wider range became again instrumental in disclosing a fresh store of useful facts. It may be said to have been the power of dexterously combining such methods which constituted the felicity of his genius; for, in general, each of them requires for its successful application a mind of quite a distinct order and construction. Mr. Babbage has very justly observed, that those intellectual qualifications which give birth to new principles or to new methods, are of quite a different order from those which are necessary for their practical application. Davy furnished the exception that was necessary to make good the rule.

He detects, in the first instance, the general principle of inflammable gas, in a state of combustion, being arrested in its progress by capillary tubes; he next applies it to the construction of a Safety-lamp, and then, by observing the phenomena which this lamp exhibits, is led to novel views respecting the nature and properties of flame.

I shall endeavour to offer a popular view of the curious and interesting truths disclosed by this latter research.

He had observed that, when the coal gas burnt in the iron cage, its colour was pale, and its light feeble; whereas the fact is rendered familiar to us all by the flame of the gas lights, that in the open air carburetted hydrogen burns with great brilliancy. Upon reflecting on the circumstances of the two species

* A short notice of them first appeared in the third number of the "Journal of Science and the Arts," edited at the Royal Institution.

of combustion, he was led to believe that the cause of the superiority of the light in the latter case might be owing to a *decomposition* of a part of the gas towards the interior of the flame, where the air was in the smallest quantity; and that the consequent deposition of charcoal might first by its *ignition*, and afterwards by its *combustion*, contribute to this increase of light. A conjecture which he immediately verified by experiment.

The intensity therefore of the light of flames depends principally upon the production and ignition of *solid* matter in combustion, so that heat and light are in this process independent phenomena.

These facts, Davy observes, appear to admit of many applications; in explaining, for instance, the appearance of different flames—in suggesting the means of increasing or diminishing their light, and in deducing from their characters a knowledge of the composition of their constituent parts.

The point of the inner blue flame of a candle or lamp urged by the blowpipe, where the heat is the greatest and the light the least, is the point where the whole of the charcoal is burnt in its gaseous combinations, without previous ignition. The flames of phosphorus and of zinc in oxygen, and that of potassium in chlorine, afford examples of intensity of light depending upon the production of *fixed* solid matter in combustion; while on the contrary, the feebleness of the light of those flames, in which gaseous and volatile matter is alone produced, is well illustrated by those of hydrogen and sulphur in oxygen, or by that of phosphorus in chlorine.

From such facts, Davy is inclined to think that the luminous appearance of shooting stars and meteors cannot be owing to any inflammation of gas, but must depend upon the ignition of solid matter. Dr. Halley calculated the height of a meteor at ninety miles, and the great American meteor, which threw down showers of stones, was estimated at only seventeen miles high. The velocity of the motion of such bodies must in all cases be immensely great, and the heat thus produced by the compression of the most rarefied air, Davy thinks, must be sufficient to ignite the mass; and that all the phenomena may be explained by assuming that *falling stars* are small solid bodies moving round the earth in very eccentric orbits, which become ignited only when they pass with immense velocity through the upper regions of the atmosphere, and which, when they contain either combustible or elastic matter, throw out stones with explosion.

By the application of such a principle did he also infer the composition of a body from the character of its flame: thus, says he, Ether, during its combustion, would appear to indicate the presence of *olefiant gas.* Alcohol burns with a flame similar to that of a mixture of carbonic oxide and hydrogen; so that the first is probably a binary compound of olefiant gas and water, and the second of carbonic oxide and hydrogen.

When the proto-chloride of copper is introduced into the flame of a candle or lamp, it affords a peculiar dense and brilliant red light, tinged with green and blue towards the edges, which seems to depend upon the separation of the chlorine from the copper by the hydrogen, and the ignition and combustion of the solid copper and charcoal.

The acknowledged fact of the brightest flames yielding the least heat is easily reconciled, when we learn that the light depends upon fixed matter which carries off the heat. It is equally obvious, that by art we may, for practical purposes, easily modify these phenomena.

In the next place, having observed that wire-gauze cooled down flame beyond its combustible point, he was led to enquire into the nature of pure flame; and he readily demonstrated it to be *gaseous matter heated so highly as to be luminous;* and that the temperature necessary for such an effect was much greater than had been imagined, varying, however, in different cases. The flame of a common lamp he proved, by a very simple experiment, to exceed even the white heat of solid bodies, and which is easily shown by the simple fact of heating a piece of platinum wire over the chimney of an Argand lamp fed with spirit of wine; when it will be seen that air, which is not of sufficient temperature to appear luminous, is still sufficiently hot to impart a white heat to a solid body immersed in it.

The fact of different gaseous bodies requiring different degrees of heat to raise them into flame, was an inference immediately deducible from the phenomena of his *safety gauze.* A tissue of one hundred apertures to the square inch, made of wire of one-sixtieth, will, at common temperatures, intercept the flame of a spirit-lamp, but not that of hydrogen; and, when strongly heated, it will no longer arrest the flame of the spirit-lamp. A tissue which, when red-hot, will not interrupt the flame of hydrogen, will still intercept that of olefiant gas; and a heated tissue, which would communicate explosion from a mixture of olefiant gas and air, will stop an explosion of fire-damp. Fortunately for the success of the Safety-lamp, carburetted hydrogen requires so high a temperature to carry on its combustion, that even metal, when white hot, is far below it; and hence red-hot gauze, in sufficient quantity, and of the proper degree of fineness, will abstract heat enough from the flame to extinguish it.

The discovery of the high temperature which is necessary for the maintenance of flame, suggested to the philosopher the reason of its extinction under various circumstances. He considers, that the common operation of blowing out a candle principally depends upon the cooling power of the current of air projected into the flame; and he observes, that the hottest flames are those which are least easily blown out. He farther illustrated this subject by surrounding a very small flame with a ring of *metal*, which had the effect of cooling it so far as to extinguish it; but a ring of *glass*, of similar dimensions and diameter, being a less perfect conductor of heat, produced no such effect.

It had been long known that flame ceased to burn in highly rarefied air; but the degree of rarefaction necessary for this effect had been very differently stated. The cause of the phenomenon was generally supposed to depend upon a deficiency of oxygen.

In the commencement of his enquiry into this subject, Davy observed that the flame of hydrogen gas, the degree of rarefaction and the quantity of air being the same, burnt longer when it issued from a larger than a smaller jet; a fact the very reverse of that which must have happened had the flame expired for want of oxygen; he moreover observed, that when the larger jet was used, the point of the glass tube became white-hot, and continued red-hot till the flame was extinguished; he therefore concluded, that the heat communicated to the gas by this tube was the cause of its protracted combustion, and that *flame expired in rarefied air, not for want of nourishment from oxygen, but for want of heat, and that if its temperature could be preserved by some supplementary aid, the flame might be kept burning.* The experiment by which he confirmed this theory was as beautiful as it was satisfactory.

He burnt a piece of camphor in a *glass* tube, under the receiver of an air pump, so as to make the upper part of the tube red-hot; its inflammation was found to continue when the rarefaction was nine times; but by repeating the experiment in a *metallic* tube, which could not be so considerably heated by it, it ceased after the rarefaction exceeded six times.

It follows then that by artificially imparting heat,* bodies may be made

* "It is upon this principle that, in the Argand lamp, the Liverpool lamp, and in the best fire-places, the increase of effect does not merely depend upon the rapid current of air, but likewise upon the heat preserved by the arrangements of the materials of the chimney, and communicated to the matters entering into inflammation." The art of making a good fire depends also upon the same principle of economising the heat.

to burn in a rarefied air, when under other circumstances they would be extinguished.

The following may be considered as an *experimentum crucis,* in proof of the fact that combustibility is neither increased nor diminished by rarefaction.

He introduced the flame of hydrogen, in which was inserted a platinum wire, into a receiver of rarefied air, and he found that, as long as the metal remained at a dull red-heat, the flame continued to burn; now it so happens that the temperature, at which platinum approaches a red-heat, is precisely that at which hydrogen inflames under the ordinary pressure of the atmosphere; whence it follows, that its combustibility is not altered by rarefaction.

The same law was found to apply to the flames of other bodies; those requiring the least heat for their combustion always sustaining the greater rarefaction without being extinguished.*

Hitherto he had only considered the effects of rarefaction, when produced by the diminution of pressure: he had next to investigate the phenomena of rarefaction when occasioned by expansion from heat.

The experiments of M. de Grotthus had apparently shown that rarefaction by heat destroys the combustibility of gaseous mixtures: those of Davy, however, proved that it enables them to explode at a lower temperature.

In the progress of this research, while passing mixtures of hydrogen and oxygen through heated tubes, the heat being still below redness, he observed that steam was formed without any combustion.

Here was a slow combination without combustion, as long since observed with respect to hydrogen and chlorine, and oxygen and metals; and he believes that such a phenomenon will happen at certain temperatures with most substances that unite by heat. On trying charcoal, he found that at a temperature which appeared to be a little above the boiling point of quicksilver, it converted oxygen pretty rapidly into carbonic acid, without any luminous appearance, and that, at a dull red-heat, the elements of olefiant gas combined in a similar manner with oxygen, slowly and without explosion.

It occurred to Davy, in the progress of these experiments, that, during this species of slow combination, although the increase of temperature might not be sufficient to render the gaseous matters luminous, or to produce flame, it

* From a calculation of the ratio in which the density of the atmosphere decreases with its altitude, and from that of the relative combustibility of different bodies, it follows that the taper would be extinguished at a height of between nine and ten miles—hydrogen, between twelve and thirteen—and sulphur, between fifteen and sixteen.

might still be adequate to ignite solid matters exposed to them. It was while engaged in devising experiments to ascertain this fact, that he was accidentally led to the discovery of the continued ignition of platinum wire, during the slow combination of coal gas with atmospheric air; the circumstances of which have been already related, as well as the curious invention to which the application of the fact gave origin.*

For this and his preceding papers on the subjects of flame and combustion, the President and Council of the Royal Society adjudged to Sir Humphry Davy the gold and silver medals, on the donation of Count Rumford;† and never, I will venture to say, did a society in awarding a prize more faithfully comply with the intentions of its founder.

On the completion of these laborious enquiries, it was thought expedient to give a wider circulation to their results than the publication of them in the Philosophical Transactions was calculated to afford; and Sir Humphry Davy was therefore induced to reprint his principal memoirs, so as to form an octavo volume,‡ which might be accessible to the practical parts of the community.

The enlightened friends of science very reasonably expected that a service of such importance to society as the invention of the Safety-lamp, would have commanded the gratitude of the state, and obtained for its author a high parliamentary reward; nor were there wanting zealous and disinterested persons

* See page 323.

† At the Anniversary of the Royal Society, November 1796, Count Rumford transferred one thousand pounds, three per cent. Consols, to the use of the Society, on condition that a premium should be biennially awarded to the author of the most important discovery, or useful invention, made known in any part of Europe during the preceding two years, on the subject of Heat and Light. In regard to the form in which this premium was to be conferred, he requested that it might always be given in two medals, struck in the same die, the one of gold, and the other of silver.

Should not any discovery or improvement be made during any terms of years, he directed that the value of the medals should be reserved, and being laid out in the purchase of additional stock, go in augmentation of the capital of this premium.

Medals upon this foundation have been successively voted to Professor Leslie, for his Experiments on Heat, published in his work entitled "An Experimental Enquiry into the Nature and Properties of Heat;"—To Mr. William Murdoch, for his publication "On the employment of Gas and Coal for the purpose of Illumination;"—to M. Malus, for his discoveries of certain new properties of reflected light;—to Dr. Wells, for his Essay on Dew;—to Sir Humphry Davy, as above stated;—to Dr. Brewster, for his Optical Investigations;—and, lastly, to Mr. Fresnel, for his optical researches.

‡ "On the Safety-lamp for Coal Mines, with some Researches on Flame.—London, 1818."

to urge the claims of the philosopher; but a Government which had bestowed a splendid pension upon the contriver of an engine* for the destruction of human life, refused to listen to any proposition for the reward of one who had invented a machine for its preservation. It is true that, in consideration of various scientific services, they tardily and inadequately acknowledged the claims of Davy, by bestowing upon him the dignity of a Baronetcy †—a reward, it must be confessed, that neither displayed any regard to his condition, nor implied the just estimate of his merits. The measure of value, however, enables us to judge of the standard by which the State rates the various services to society; and deeply is it to be lamented that the disproportioned exaltation of military achievement, crowned with the highest honours, depresses respect for science, and raises a false and fruitless object of ambition.

The passion for arms is a relict of barbarity derived from the feudal ages; the progress of civilization, and the cultivation of the mind, should have led us to prefer intellectual to physical superiority, and to recognise in the successes of science the chief titles to honour. This reversal of the objects of importance can never be redressed until the aristocracy shall be possessed of a competent share of scientific knowledge, and instructed to appreciate its value. To effect such a change, the system of education so blindly and obstinately continued in our great public schools, must be altered; for minds exclusively applied to classical pursuits, and trained to recognise no other objects of liberal study, are indisposed and indeed disqualified for enquiries ministering to the arts of life, and arrogantly despised for their very connexion with utility. It is in the early ignorance of the rudiments of science that the after negligence of science has its source.

The instances in proof of the extent of the ignorance and indifference I have noted, and of their pernicious effects upon the most important interests of society, especially legislation, and the administration of justice, are abundant. In Parliament, how is a question of science treated? In our courts of law, and criminal investigation, it is lamentable to observe the frequent defeat of justice, arising from erroneous conception, or from the utter absence of the requisite knowledge. In the ordinary affairs of life, we see conspicuous,

* Sir William Congreve, in addition to other marks of favour, received a pension of twelve hundred a-year, for the invention of his Rocket; or, in the exact terms of the grant, "for inventions calculated to destroy or annoy the enemy."

† He was created a Baronet on the 20th of October, 1818.

amongst the dupes of quackery and imposture, those whose stations should imply the best instruction, and whose conduct, unfortunately, has the effect of example.

A contempt far-spreading, and proceeding from the well-springs of truth, is rapidly rising against this exalted ignorance; the industrious classes of society are daily becoming more imbued with knowledge upon scientific subjects, and the nobility, if they would preserve their superiority in social consideration, must descend to the popular improvement.

Before concluding the present chapter, I must carry back my history to the year 1815, for the purpose of recording a circumstance in the life of Davy which, while it exemplifies his general love of science, evinces the local attachment he retained for the town of his birth.

In the year 1813, the Geological Society of Cornwall was established at Penzance. Its objects are to cultivate the sciences of Mineralogy and Geology, in a district better calculated perhaps for such pursuits than any other spot in Europe,—to register the new facts which are continually presenting themselves in the mines, and to place upon permanent record, the history of phenomena which had hitherto been entrusted to oral tradition; but, above all, its object was to bring science in alliance with art; to prevent the accidents which had so frequently occurred from explosion in the operation of blasting rocks; and, in short, to render all the resources of speculative truth subservient to the ends of practical improvement.

No sooner had the establishment of so useful an institution been communicated to Davy, than he testified his zeal for its welfare by a handsome donation to its funds; which was followed by a present of a very extensive suite of specimens, illustrative of the volcanic district of Naples, and which had been collected by himself. He also afterwards communicated to the Society a memoir on the Geology of Cornwall, which has been published in the first volume of its Transactions.

In this paper, he discusses several of the more difficult questions connected with the origin of veins.

He first observed the granitic veins, which have called forth so much attention from geologists, about the year 1797; probably before they had excited much scientific notice: he is disposed to regard them as peculiar to the low metalliferous granite and mica formations; he had seen several cases of granite veins near Dublin, in the Isle of Arran, and in other parts of Scotland; he had also observed several instances near Morlaix in Brittany, but he had in vain searched for them in the points of junction of the schist and granite, both in the Maritime, Savoy, Swiss, and Tyrolese Alps, and likewise in the Oriental Pyrenees.

The *serpentine* district of Cornwall, he thinks, has not yet met with the attention it deserves. "I have seen no formation," says he, "in which the nature of serpentine is so distinctly displayed. The true constituent parts of this rock appear to be *resplendent hornblende* and *felspar;* it appears to differ from *sienite* only in the nature of the *hornblende*, and in the chemical composition of its parts, and in being intersected by numerous veins of *steatite* and *calcareous spar*."

The nature and origin of the veins of *steatite* in serpentine, he considers as offering a very curious subject for enquiry. "Were they originally crystallized?" he asks, "and the result of chemical deposition? or have they been, as for the most part they are now found, mere mechanical deposits?" He is inclined to the latter opinion. The felspar in serpentine, he observes, is very liable to decomposition, probably from the action of carbonic acid and water on its alkaline, calcareous, and magnesian elements; and its parts washed down by water and deposited in the chasms of the rocks, he thinks would necessarily gain that kind of loose aggregation belonging to steatite.

He had some years before made a rude, comparative analysis of the felspar in serpentine, and of the soap-rock, when he found the same constituents in both of them, except that there was not any alkali or calcareous earth in the latter substance. It is very difficult to conceive, he says, that steatite was originally a crystallized substance which has been since decomposed; for, in that case, it ought to be found in its primitive state in veins which are excluded from the action of air and water; whereas it is easy to account for the hardness of some species of steatite on the former hypothesis; for mere mechanical deposits, when very finely divided, and very slowly made, adhere with a very considerable degree of force. A remarkable instance of this kind occurred to him amongst the chemical preparations of the late Mr. Cavendish, which, on the decease of that illustrious philosopher, had been presented to him by Lord George Cavendish: there was a bottle which had originally contained a solution of silica by potash; the cork, during the lapse of years, had become decayed, and the carbonic acid of the atmosphere had gradually precipitated the earth, so that it was found in a state of solid cohesion; the upper part was as soft as the steatite, but the lower portion was extremely hard, was broken with some difficulty, and presented an appearance similar to that of chalcedony.

In speaking generally of the mineralogical interest of Cornwall, he observes, that "it may be regarded, κατ' ἐξοχην, as the country of veins; and that it is in veins that the most useful as well as the most valuable minerals generally exist, that the pure specimens are found which serve to determine the mineralogical species, and that the appearances seem most interesting in their connexion with geological theory. Thus veins, which now may be considered in the light of the most valuable cabinets of nature, were once her most active laboratories; and they are equally important to the practical miner, and to the mineralogical philosopher."

With regard to the general conformation of Cornwall, he states it to be in the highest degree curious, and he considers that the facts which it offers are illustrative of many important points of geological theory. "It exhibits very extraordinary instances of rocks broken in almost every direction, but principally from east to west, and filled with veins again broken in, diversified by cross lines, and filled with other veins, and exhibiting marks of various successive phenomena of this kind.

"Respecting the agents that produced the chasms in the primary strata, and the power by which they were filled with stony and metallic matter, it would be easy to speculate, but very difficult to reason by legitimate philosophical induction."

In the concluding passage, however, he very freely admits his preference for the doctrine of fire.

"It is amongst extinct volcanoes, the surfaces of which have been removed by the action of air and water, and in which the interior parts of strata of lavas are exposed, that the most instructive examples of the operation of slow cooling upon heated masses are to be found. It is difficult to conceive that water could have been the solvent of the different granitic and porphyritic formations; for, in that case, some combinations of water with the pure earths ought to be found in them. Quartz ought to exist in a state of *hydrate*, and Wavellite, not Corundum, ought to be the state of alumina in granite.

"To suppose the primary rocks, in general, to have been produced by the slow cooling of a mass formed by the combustion of the metallic bases of the earths, appears to me the most reasonable hypothesis; yet aqueous agency must not be entirely excluded from our geological views. In many cases of crystallization, even in volcanic countries, this cause operates; thus in Ischia, siliceous *tufas* are formed from hot springs ; and in the lake Albula, or the lake of Solfaterra, near Tivoli, crystals of calcareous spar and of sulphur separate from water impregnated with carbonic acid and hepatic gas; and large strata of calcareous rocks, formed evidently in late times by water impregnated with carbonic acid, exist in various parts of Europe. The Travertine marble *(Marmor Tiburtinum)* is a production of this kind; and it is of this species of stone that the Coliseum at Rome, and the cathedral of St. Peter, are built. It is likewise employed in the ancient temple of Pæstum, and it rivals in durability, if not in beauty, the primary marble of Paris and Carrara.

CHAPTER XII.

Sir Humphry Davy suggests a chemical method for unrolling the ancient Papyri.—He is encouraged by the Government to proceed to Naples for that purpose.—He embarks at Dover.—His experiments on the Rhine, the Danube, the Raab, the Save, the Ironzo, the Po, and the Tiber, in order to explain the formation of mists on rivers and lakes.—His arrival and reception at Naples.—He visits the excavations at Herculaneum.—He concludes that it was overwhelmed by sand and ashes, but had never been exposed to burning matter.—He commences his attempt of unrolling the Papyri.—His failure.—He complains of the persons at the head of the department in the Museum.—He analyses the waters of the baths of Lucca.—His return to England.—Death of Sir Joseph Banks.—He is elected President of the Royal Society.—Some remarks on that event.—He visits Penzance.—Is honoured by a public dinner.—Electro-magnetic discoveries of Oersted extended by Davy.—He examines Electrical Phenomena in vacuo.—The results of his experiments questioned.—He enquires into the state of the water, and aëriform matter in the cavities of crystals.—The interesting results of his enquiry confirm the views of the Plutonists.

Our history now proceeds to exhibit Sir Humphry Davy in quite a new field of enquiry ;—engaged in investigating, amidst the ruins of Herculaneum, the nature and effects of the volcanic eruption which overwhelmed that city in the reign of Titus ; and in attempting, by the resources of modern science, to unfold and to render legible the mouldering archives which have been recovered from its excavations, and deposited in the Museum at Naples.

Having witnessed the unsuccessful attempts of Dr. Sickler to unroll some of the Herculaneum manuscripts, it occurred to him that a chemical examination of their nature, and of the changes they had undergone, might suggest some method of separating the leaves from each other, and of rendering legible the characters impressed upon them. On communicating this opinion to Sir Thomas Tyrwhitt, he immediately placed at his disposal fragments which had been operated upon by Mr. Hayter and by Dr. Sickler: at the same time, Dr. Young presented him with some small pieces, which he himself had formerly attempted to unroll.

Davy was very soon convinced by the products of their distillation, that the nature of these manuscripts had been generally misunderstood; that they had not, as was usually supposed, been carbonized by the operation of fire, but were in a state analogous to peat, or to Bovey coal, the leaves being generally cemented into one mass by a peculiar substance which had formed, during the fermentation and chemical change of the vegetable matter composing them, in a long course of ages. The nature of this substance being once known, the destruction of it would become a subject of obvious chemical investigation.

It occurred to him, that as chlorine and iodine do not exert any action upon pure carbonaceous substances, while they possess a strong attraction for hydrogen, these bodies might probably be applied with success for the purpose of destroying the adhesive matter, without the possibility of injuring the letters of the Papyri, the ink of the ancients, as it is well known, being composed of charcoal. He accordingly exposed a fragment of a brown manuscript, in which the layers were strongly adherent, to an atmosphere of chlorine; there was an immediate action, the papyrus smoked, and became yellow, and the letters appeared much more distinct. After which, by the application of heat, the layers separated from each other, and fumes of muriatic acid were evolved. The vapour of iodine had a less distinct, but still a very sensible action. By the simple application of heat to a fragment in a close vessel filled with carbonic acid, or with the vapour of ether, so regulated as to raise the temperature very gradually, and as gradually to reduce it, there was a marked improvement in the texture of the papyrus, and its leaves were more easily unrolled. In all these preliminary trials, however, he found that the success of the experiment absolutely depended upon the nicety with which the temperature was regulated.

Different papyri having exhibited different appearances, he concluded that the same process would not apply in all cases; but even a partial success he considered as a step gained, and it served to increase his anxiety to examine in detail the numerous specimens preserved in the Museum at Naples, as well as to visit the excavations that still remained open at Herculaneum.

Mr. Hamilton, to whom these views were communicated, with that ardour which belongs to his character, entered warmly into a plan which might enable Sir Humphry Davy to accomplish his objects; and on his representation of them, the Earl of Liverpool and Viscount Castlereagh placed at his disposal such funds as were requisite for paying the persons whom it was necessary to engage in the process.

At the same time, Sir Humphry Davy had the honour of an audience of his late Majesty, then Prince Regent; and on witnessing the results, his Royal Highness was pleased to express his approbation, and graciously condescended to patronize the undertaking. Exulting in the prospect of success, and sanguine as to the importance of its results to literature, Davy embarked at Dover for the Continent, in order to proceed to Naples, on the 26th of May 1818.

During his journey, he was engaged in making observations on the comparative temperature of air incumbent upon land and water, with a view to account for the formation of mists over the beds of rivers and lakes. The results of this enquiry were embodied in a memoir, which was read before the Royal Society on the 25th of February 1819, and published in the Philosophical Transactions of that year. This paper, while it records the course of his observations, informs us of the direction of his route to the southern shores of Italy.

On the 31st of May, while passing along the Rhine from Cologne to Coblentz, we find him examining the relative temperature of the air, and of the water of that river. On the 9th, 10th, and 11th of June, he was making similar observations on the Danube, during a voyage from Ratisbonne to Vienna. On the 11th of July, he was similarly engaged on the Raab, near Kermond in Hungary. In the end of August he was on the Save in Carniola; in the middle of September on the Ironzo in the Friul; in the end of that month, on the Po, near Ferrara; and in the beginning of October, repeatedly on the Tiber, and on the small lakes in the Campagna of Rome, extending and multiplying his observations upon the formation of mists: from the results of which he established the law, that the formation of mist, on a river or lake, never takes place, if the temperature of the water be lower than that of the atmosphere; not even though the latter should be even saturated with vapour.

Possessed of this fact, he was enabled to explain a phenomenon which all persons who have been accustomed to the observation of Nature must have frequently witnessed, although it had never yet been philosophically explained, nor even fully discussed, viz.—the formation of mists over the beds of rivers and lakes, in calm and clear weather, after sunset.

Sir Humphry Davy thinks that whoever has considered the phenomena in relation to the radiation and communication of heat and nature of vapour, since the publication of the researches of MM. Rumford, Leslie, Dalton, and Wells, can scarcely have failed to discover their true causes.

"As soon as the sun has disappeared from any part of the globe, the surface begins to lose heat by radiation, and in greater proportions as the sky is clearer; but the land and water are cooled by this operation in a very different manner: the impression of cooling on the land is limited to the surface, and very slowly transmitted to the interior; whereas in water above 45° Fah., as soon as the upper stratum is cooled, whether by radiation or evaporation, it sinks in the mass of fluid, and its place is supplied by warmer water from below, and till the temperature of the whole mass is reduced nearly to 40°, the surface cannot be the coolest part.* It follows, therefore, that wherever water exists in considerable masses, and has a temperature nearly equal to that of the land, or only a few degrees below it, and above 45° at sunset, its surface during the night, in calm and clear weather, will be warmer than that of the contiguous land; and the air above the land will necessarily be colder than that above the water; and when they both contain their due proportion of aqueous vapour, and the situation of the ground is such as to permit the cold air from the land to mix with the warmer air above the water, mist or fog will be the result; which will be so much the greater in quantity, as the land surrounding or inclosing the water is higher, the water deeper, and the temperature of the water, which will coincide with the quantity or strength of vapour in the air above it, greater."

It will be remembered, that the rivers Inn and Ilz flow into the Danube below Passau; a circumstance which afforded Davy an excellent opportunity of confirming, by observation and experiment, the truth of his theory. On examining the temperature of these rivers, at six o'clock A. M. June 11, that of the Danube was found to be 62°, that of the Inn 56.5°, and that of the Ilz 56°: the temperature of the atmosphere on the banks, where their streams mixed, was 54°. The whole surface of the Danube was covered with a thick fog; on the Inn there was a slight mist; and on the Ilz barely a haziness, indicating the deposition of a very small quantity of water. About one hundred yards below the conflux of the rivers, the temperature of the central part

* Water, when cooled down to 40°, expands in volume, and thus becomes specifically lighter; and therefore at that temperature remains at the surface.

of the Danube was 59°; and here the quantity of mist was less than on the bed of the Danube before the junction; but about half a mile below, the warmer water had again found its place at the surface, and the mist was as copious as before the union of the three rivers.

After mists have been formed above rivers and lakes, Davy considers that their increase may not only depend upon the constant operation of the cause which originally produced them, but likewise upon the radiation of heat from the superficial particles of water composing the mist, which produces a descending current of cold air in the very body of the mist, while the warm water continually sends up vapour. It is to these circumstances, he says, that the phenomena must be ascribed of mists from a river or lake sometimes arising considerably above the surrounding hills. He informs us that he had frequently witnessed such an appearance during the month of October, after very still and very clear nights, in the Campagna of Rome above the Tiber, and on Monte Albano, over the lakes existing in the ancient craters of this extinguished volcano; and in one instance, on the 17th of October, before sunrise, there not being a breath of wind, a dense white cloud, of a pyramidal form, was seen on the site of Alban Lake, and rising far above the highest peak of the mountain. Its form gradually changed after sunrise; its apex first disappeared, and its body, as it were, melted away in the sunbeams.

Great dryness of the air, or a current of dry air passing across a river, he found, as we might have expected, to prevent the formation of mist even when the temperature of the water was much higher than that of the atmosphere.

Thus did our philosopher, during the course of his journey to Naples, by a series of observations and experiments, investigate a phenomenon connected with the deposition of water from the atmosphere, and which is not without an effect in the economy of nature; for verdure and fertility, in hot climates, generally follow the courses of rivers, and, by the operation of the law he established, they are extended to the hills, and even to the plains surrounding their banks.

On his arrival at Naples, Sir H. Davy found that a letter from his Royal Highness the Prince Regent to the King, and a communication made from the Secretary of State for Foreign Affairs to the Neapolitan Government, had prepared the way for his enquiries, and procured for him every possible facility in the pursuit of his objects.

The different rolls of papyri presented very various appearances. They were of all shades, from a light chestnut brown to a deep black; some externally were of a glossy black, like jet, which the superintendents called "varnished;" several contained the umbilicus, or rolling-stick, in the middle, converted into dense charcoal. In their texture, also, they were as various as in their colours.

The persons to whom the care of these MSS. are confided, or who have worked upon them, have always attributed these different appearances to the action of fire, more or less intense, according to the proximity of the lava, which has been imagined to have covered the part of the city in which they were found; but the different conclusion at which Davy had arrived, from a chemical examination in England, was confirmed by a visit to the excavations that still remained open at Herculaneum.

These excavations are in a loose *tufa*, composed of sand, volcanic ashes, stones, and dust, cemented by the operation of water, which, at the time of its action, was probably in a boiling state. The theatre, and the buildings in the neighbourhood, are incased in this *tufa*, and, from the manner in which it is deposited in the galleries of the houses, there can be little doubt that it was the result of torrents laden with sand and volcanic matter, and descending, at the same time, with showers of ashes and stone still more copious than those that covered Pompeii. The excavation in the house in which the MSS. were found, had been filled up; but a building, which was said by the guides to be this house, and which, as is evident from the engraved plan, must at least have been close to it, at once convinced Davy that the parts nearest the surface, and, *à fortiori*, those more remote from it, had never been exposed to any considerable degree of heat. He found a small fragment of the ceiling of one of the rooms, containing lines of gold leaf and vermilion, in an unaltered state, which never could have happened had they been acted upon by any temperature sufficiently great to convert vegetable matter into charcoal.

The different states of the MSS. exactly coincide with this view, and furnish evidence of their having undergone a gradual process of decomposition. The loose chestnut papyri, he observes, were probably never wetted, but merely changed by the reaction of their elements, assisted by the operation of a small quantity of air; the black ones, which easily unroll, may be supposed to have remained in a moist state, without any percolation of water; while it is likely that the dense ones, containing earthy matter, have been acted on by warm water, which not only carried into the folds earthy matter suspended in it, but likewise dissolved the starch and gluten used in preparing the papyrus and the glue of the ink, and distributed them through the substance of the MSS.

As many of the papyri appear to have been strongly compressed when moist, in different positions, he thinks it probable that they had been placed on shelves of wood, which were broken down when the roofs of the houses yielded to the superincumbent mass. That the operation of fire is not at all necessary for producing such an imperfect carbonization of vegetable matter as that displayed by the MSS., is at once proved by an inspection of the houses at Pompeii, which was covered by a shower of ashes that must have been cold, as they fell at the distance of seven or eight miles from the crater of Vesuvius; and yet the wood of its buildings is uniformly found converted into charcoal, while the colours on the walls, most of which would have been destroyed or altered by heat, are perfectly fresh. Where papyri have been found in these houses, they have appeared in the form of white ashes, as of burnt paper, an effect produced by the slow action of the air penetrating through the loose ashes, and which has been impeded or prevented in Herculaneum by the *tufa*, which, as it were, hermetically sealed up the town, and prevented any decay, except such as occurs in the spontaneous decomposition of vegetable substances exposed to the limited operation of water and air—for instance, peat and Bovey coal.

Davy ascertained, that what the Neapolitans called varnish, was decomposed skin that had been used to infold some of the papyri, and which by chemical changes had produced a brilliant animal carbonaceous substance, which afforded by distillation a considerable quantity of ammonia, and left ashes containing much phosphate of lime.

Only one method, and that a simple and mechanical, though a highly ingenious one, had been adopted for unrolling the MSS. It was invented, in the middle of the last century, by Padre Piaggi, a Roman. and consists in attaching a thin animal membrane, by a solution of glue, to the back of the MSS. and then carefully elevating the layers by silk threads, which are gradually moved by the revolution of wooden pegs. Davy, shortly after his arrival, desired that the process of unrolling might be continued in his presence; and in considering the method in its general application, it occurred to him that some expedient might be used to facilitate the separation of the layers. For this purpose, he proposed to mix the solution of glue with a sufficient quantity of alcohol to gelatinize it, in order that it might not penetrate through three or four layers, which it was liable to do, when the texture of the papyrus was loose or broken, and the glue employed was in a liquid state. He also suggested the application of warm air for drying the papyrus, in the operation of attaching the membrane. It is not my intention to follow the chemist through all the various processes which he instituted for accomplishing his object; they may, however, be found in his paper entitled "Some Observations and Experiments on the Papyri found in the Ruins of Herculaneum," which was read before the Royal Society on the 15th of March 1821, and published in the Transactions of that year.

It only remains to be stated that Davy was not successful; but though the process of unrolling hitherto applied may not have received any considerable improvement from his science, and though he may not have succeeded in rendering any of the manuscripts legible, the failure is not to be attributed to his want of zeal, or to his want of skill, but solely, as it is generally admitted, to the unfortunate condition of the papyri.

It will be readily supposed that a failure in an investigation, from which he had anticipated so much advantage, was not sustained by a person naturally quick and irritable, without some demonstrations of impatience and dissatisfaction.

It was probably under the influence of such feelings, that he composed the conclusion of his memoir. "During the two months that I was actively employed in experiments on the papyri at Naples, I had succeeded, with the assistance of six of the persons attached to the Museum, and whom I had engaged for the purpose, in partially unrolling twenty-three MSS., from which fragments of writing were obtained, and in examining about one hundred and twenty others, which afforded no hopes of success; and I should gladly have gone on with the undertaking, from the mere prospect of a possibility of discovering some better result, had not the labour, in itself difficult and unpleasant, been made more so, by the conduct of the persons at the head of this department in the Museum. At first, every disposition was shown to promote my researches; for the papyri remaining unrolled were considered by them as incapable of affording any thing legible by the former methods, or, to use their own word, *disperati;* and the efficacy and use of the new processes were fully allowed by the *Svolgatori*, or unrollers of the Museum; and I was some time permitted to choose and operate upon the specimens at my own pleasure. When, however, the Reverend Peter

Elmsley, whose zeal for the promotion of ancient literature brought him to Naples for the purpose of assisting in the undertaking, began to examine the fragments unrolled, a jealousy with regard to his assistance was immediately manifested; and obstacles, which the kind interference of Sir William A'Court was not always capable of removing, were soon opposed to the progress of our enquiries; and these obstacles were so multiplied, and made so vexatious towards the end of February, that we conceived it would be both a waste of the public money and a compromise of our own characters to proceed."

While in Italy, Sir H. Davy visited the baths of Lucca, and examined the waters which have given to that place so much celebrity. The results of his analysis formed the subject of a paper, which was published in the Memoirs of the Royal Academy of Sciences at Naples, of which society he was a member.

At the spot where the temperature of the water was the highest, that is, in what are termed the *Caldi*, or hot baths, a considerable quantity of a substance is ejected, which produces a deposit of a brownish-yellow colour. Having collected a quantity of this deposit, he ascertained it to consist of oxide of iron and silica, in the proportion of about four parts of the former to three of the latter; and although the iron, at the time of its deposition, proved to be a *peroxide*, he thinks it probable that it existed in the water in the state of *protoxide*. He also supposes, that the oxide of iron and the silica had been dissolved together in the water, and been deposited from it in combination. He conceives that the fact which he had some years before noticed, of the analogy between the base of silica and that of boracic acid, together with those observed by Berzelius, furnish sufficient reasons for classing silica amongst the acids, and for rendering it probable, that the oxide of iron and silica undergo a real chemical combination in the warm water, and that they are separated from the latter in consequence of the reduction of its temperature, after it has issued from the mountain.

A small portion of oxide of iron, he observes, is found in the waters of Bath, in which case it is also accompanied by silica; and he believes that, in many other instances, the oxide of iron is dissolved in water through the same agency; he moreover regards such facts as throwing considerable light upon the manner in which ochre is generated.

Sir Humphry Davy returned to England in 1820; and, on the 19th of June, in the same year, his venerable friend Sir Joseph Banks, who, notwithstanding his increasing infirmities, had continued to discharge the duties of President of the Royal Society to the latest period of his life, expired at his villa at Spring Grove, at the advanced age of seventy-seven.

Discussions necessarily arose as to the appointment of a proper successor, when persons of high and even exalted rank were proposed as candidates; but the more influential members of the Society at once found, in their own Council-chamber, two philosophers, whom they considered equally entitled to the honour of the situation, and equally well calculated for the discharge of its duties—Sir Humphry Davy, and Dr. Wollaston; but the latter having signified his fixed determination to decline competition, gave the whole weight of his influence to the former; and, under that arrangement, he received from the Council the compliment of being placed in the chair, until the general election of officers at the ensuing anniversary.

As the period of election approached, a few Fellows of the Society attempted to raise a clamour in favour of some more aristocratic candidate. To this circumstance, Davy alludes in the following letter.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Grosvenor Street, June 1820.

I REGRET very much that you could not join me at dinner this day. To-morrow and the following day I shall be occupied by pressing affairs; but I shall be at home to-morrow till half-past eleven, and be most happy to see you.

I am not very anxious to remove "mists," for I feel that the President's chair, after Sir Joseph, will be no light matter; and unless there is a strong feeling in the majority of the body that I am the most proper person, I shall not sacrifice my tranquillity for what cannot add to my reputation, though it may increase my power of being useful.

I feel it a duty that I owe to the Society to offer myself; but if they do not feel that they want me, (and the most active members, I believe, do) I shall not force myself upon them.

I am, my dear Poole, very sincerely yours,

H. DAVY.

On the day of election, (November 30, 1820,) there was a feeble expression in favour of Lord Colchester, who was abroad at the time, and had not even been made acquainted with the intention of his supporters. Davy was therefore elected by an immense majority of votes. He was conducted into the meeting-room by his two friends, Mr. Davies Gilbert and Mr. Hatchett, and, to the gratification of every lover of science, he ascended the chair of Newton.

The value which he himself attached to this triumph, may be seen in his answer to a letter of congratulation from his friend, Mr. Poole.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Grosvenor Street, Dec. 10.

I AM much obliged to you for your congratulations. The contest to my election defeated itself, for there were only thirteen votes for Lord Colchester out of nearly one hundred and sixty; and, had it been known that the attempt would have been made, I should have had at least double the number. The overwhelming majority has, however, shown the good opinion of the Society, which I trust and feel has not been diminished by my conduct in the chair.

I have never needed any motive to attach me to science, which I have pursued with equal ardour under all circumstances, for its own sake, and for the sake of the public, uninfluenced by the fears of my friends, or the calumnies of my enemies. I glory in being in the chair of the Royal Society, because I think it ought to be a reward of scientific labours, and not an appendage to rank or fortune; and because it will enable me to be useful in a higher degree in promoting the cause of science. To this cause, however, I should have been always attached, even had I not been in such good humour with the public, as I have reason to be.

Dr. Wollaston, my only formidable opponent in the beginning of the business, behaved like a true philosopher and friend of science; and Mr. Gilbert gave me his warmest support.

I am sorry that I have said so much about myself, but your long letter called for something. I wish I could say anything satisfactory on the subject of Captain Parry and his officers.* I have every reason to believe Lord Melville will do all he can on the occasion; no recommendation will be wanting from the Royal Society that can be given; but the Admiralty is bound

* Mr. Poole informs me, that he "had been anxious to interest him, as President of the Royal Society, in favour of those brave and scientific navigators, particularly Lieutenant, now Captain, Liddon, who commanded the Griper, in Captain Parry's first voyage."

by certain general rules, and will not do more in this instance than they would do in the case of a brilliant combat; but these brave and scientific navigators will be rewarded by a more durable species of glory.

Lady Davy joins me in kind remembrances.

I am, my dear Poole, sincerely yours,

H. Davy.

It was a question anxiously discussed by the friends of Davy, how far his elevation to the chair of the Royal Society was calculated to advance the cause of science, or to increase the lustre of his own fame. It will be readily perceived that this is a question perplexed by various conflicting interests, for it not only involves considerations relating to the character of the person, but to that also of the constitution and objects of the Society over which he is called upon to preside.

It is still doubtful whether the Royal Society, in the present advanced state of science, can derive advantage from possessing in its President, a philosopher actively engaged in any one branch of experimental enquiry. Sir Humphry Davy, in his first address from the chair, took occasion to observe, that "in the early periods of the establishment, when apparatus was procured with difficulty, when the greatest philosophers were obliged to labour with their own hands to frame their instruments, it was found expedient to keep in the rooms of the Society a collection of all such machines as were likely to be useful in the progress of experimental knowledge; and curators and operators were employed, by whom many capital experiments were made under the eyes of the Society.* But since the improvement of the mechanical and chemical arts has afforded greater facilities as to the means of carrying on experimental research, the transactions of the Fellows, recorded by the Society, have, with some few exceptions, been performed in their own laboratories, and at their own expense."

In deciding upon the qualifications necessary for a President, this altered

* The Charter of the Royal Society states that it was established for the improvement of NATURAL science. This epithet "*natural*" was originally intended to imply a meaning of which very few persons, I believe, are aware. At the period of the establishment of the Society, the arts of witchcraft and divination were very extensively encouraged; and the word natural was therefore introduced, in contradistinction to *super*-natural.

Although Sir Walter Scott, in his Demonology, alludes to the influence of this Society in diminishing the reigning superstition, he does not appear to have been acquainted with the circumstance here alluded to.

state of the Society must not be overlooked; nor can it be concealed, that the great discoveries of modern science have been achieved without any direct assistance from the Royal Society. Davy would have discovered the laws of electro-chemistry, and applied them for the decomposition of the alkalies—and the genius of Dalton would, by his atomic doctrine, have "snatched the science from the chaos of indefinite combination, and have bound it in the chains of number," had the Society never existed. At the same time, it must be allowed that, although it may not have directly advanced the progress of science, it has materially assisted its cause, by perpetuating the spirit of philosophical enquiry, and the love of scientific glory—by keeping alive upon the altar the sacred flame that genius may have kindled.

In the present state of science, the Royal Society imparts an inspiring principle to its various branches, by affording a rallying point, a centre of communication, to the philosophers of all nations, to whom kindred pursuits may render personal intercourse beneficial; and it becomes the paramount duty of the chief of this great republic so to preside over its arrangements, as to foster and encourage such an alliance. To this end, he must promote feelings of mutual kindness and liberality; and as the friend and umpire to all parties, it is his office to settle disagreement, to soothe disappointment, to kindle hope, and to subdue the vehemence which "engenders strife," in order that rivalship shall not pass into hostility, nor emulation degenerate into envy. It is evident that the talents and qualifications necessary for the discharge of such duties are of the highest order, extensive in their range, and diversified in their character. To which, however harshly the word may grate upon the ear of the philosopher, WEALTH must be considered as an essential and indispensable condition.

It may be fairly asked, whether a philosopher actively engaged in the pursuit of any branch of science, is so well adapted for the performance of such varied duties, as the person who possesses a general acquaintance with every department, but is not exclusively devoted to the investigation of any one branch; for, however correct may be his decisions, or unbiassed his judgment, the conduct of the former will ever be open to the charge of partiality, and the bare existence of such a suspicion, though it may be wholly groundless, will carry with it a train of evils. It is not in human nature to believe that the looker-on, and he who plays the game, are alike indifferent to the cards.*

* I state this opinion with the greater confidence, from a conviction that it is not singular. On conversing lately upon the subject with a gentleman to whom the Royal Society is deeply indebted

On the other hand, it may be urged with some force, that the Presidency of the Royal Society should be reserved as the fair reward of scientific labours, and not as an appendage to rank or to wealth :—that in England, we may in vain search amongst the aristocracy for one who feels a dignified respect for the sciences, and who is willing to afford that time which the faithful discharge of its duties would require.

To assert that Davy retained his popularity, or to deny that he retired from the office under the frown of a considerable party, would be dishonest. I would willingly dismiss this part of his life without too nice an examination ; but I am writing a history, not an eloge.

As a philosopher, his claims to admiration and respect were allowed in all their latitude; but when he sought for the homage due to patrician distinction, they were denied with indignation. How strange it is, that those whom Nature has placed above their fellow men by the god-like gift of genius, should seek from their inferiors those distinctions which are generally the rewards of fortune. When we learn that Congreve, in his interview with Voltaire, prided himself upon his fashion rather than upon his wit ; that Byron was more vain of his heraldry than of his "Pilgrimage of Childe Harold ;" that Racine pined into an atrophy, because the monarch passed him without a recognition in the anti-room of the palace, and that Davy sighed for patrician distinction in the chair of Newton, we can only lament the weakness from which the choicest spirits of our nature are not exempt. Will philosophers never feel, with Walpole, that "a genius transmits more honour by blood than he can receive ?" Had the blood of forty generations of nobility flowed in the veins of Davy, would his name have commanded higher homage, or his discoveries have excited greater admiration ? But great minds have ever had their points of weakness : an inordinate admiration of hereditary rank was the cardinal deformity of Davy's character ; it was the centre from which all his defects radiated, and continually placed him in false positions, for the man who rests his claims upon doubtful or ill-defined pretensions, from a sense of his insecurity, naturally becomes jealous at every apparent inattention, and he is suspicious of the sincerity of that respect which he feels may be the fruit of usurpation. If with these circumstances we take into consideration the existence of a natural timidity of character, which he sought to conquer by efforts that betrayed him into awkwardness of manner, and com-

for the sound judgment and discretion he displayed on occasions greatly affecting its interests, he replied, " Sir, we require not an Achilles to fight our battles, but an Agamemnon to command the Greeks."

bine with it an irritability of temperament which occasionally called up expressions of ill-humour, we at once possess a clue by which we may unravel the conduct of our philosopher, and the consequences it brought upon himself during his presidency of the Royal Society. Nor must we leave out of sight that inattention to certain forms, which, amongst those who are incapable of penetrating beyond the surface of character, passes for the offensive carelessness of superiority. Davy, after the example of Sir Joseph Banks, opened his house on one evening of the week for the reception of the Fellows of the Royal Society, and of other persons who were actively engaged in any scientific pursuit; but the invitations to these *soirées* were so irregularly managed, that they frequently gave offence, where they were intended to convey a compliment.

Conflicting opinions, respecting the management of the Royal Institution, most unfortunately also arose, and the President of the Royal Society, presuming upon his former alliance with that establishment, and upon the high obligations conferred upon it by the splendid discoveries he had achieved within its walls, was encouraged to exercise an authority which provoked an angry dissatisfaction;—schisms arose, and the party-spirit thus kindled in Albemarle Street soon spread to Somerset House.—But let us turn to the brighter part of the picture. In the discharge of the more important duties of his office, the Society received the full benefit of his talents and his virtues. At its meetings, he was constant in attendance, and dignified in his conduct and deportment; in its councils, he was firm in his resolves, correct in his judgments, zealous in his plans,* and impartial in his decisions. It has been said that he unduly favoured the pursuits of chemistry, to the injury and depression of the other branches of science: this is not the fact, as a reference to the Philosophical Transactions will amply testify; and the awards of the Copley medals will moreover show, that he alike extended the animating influence of his patronage to every part of natural philosophy. I am authorised by Sir James South to state, that during his negociations with the government, for the purpose of securing to the British Nation the unalienable use of his splendid instruments by the erection of a permanent observatory, Sir Humphry Davy was indefatigable in his exertions to accomplish so important an object; and that on one occasion, in the midst of severe illness, he travelled at no inconsiderable risk to London, from the distant seat of

* It was well known to his friends that, had his health not declined, he would have carried into effect a reform which he had long contemplated, and by which the Royal Society would have become, at once, more dignified and more useful.

his friend Mr. Knight, to advocate a cause so essential, in his judgment, to the interests of Astronomy.

In the Autumn of 1821, Davy visited his mother and relatives at Penzance; upon which occasion he received from the inhabitants of the town, and from the gentlemen resident in its neighbourhood, a flattering testimony of respect, which made a deep and lasting impression upon his heart.

At a General Meeting, summoned for the purpose of taking into consideration some mode by which his fellow-townsmen might express their sense of his transcendent talents, and of the lustre which his genius had cast upon the place of his nativity :—It was unanimously RESOLVED—

"That a public dinner be given to Sir Humphry Davy, and that the Mayor be desired to wait upon him forthwith, in order to communicate the Resolution, and respectfully to request that he would appoint the day, on which it would be agreeable to him to meet their wishes."

On the day appointed, a deputation of Gentlemen proceeded in their carriages to the house of his mother, for the purpose of conducting him to the Hotel, where an appropriate entertainment had been provided for the occasion.

The following letter evinces the sincere satisfaction which this visit afforded him.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Penzance, July 28, 1821.

AN uncontrollable necessity has brought me here. Close to the Land's-end I am enjoying the majestic in nature, and living over again the days of my infancy and early youth.

The living beings that act upon me are interesting subjects for contemplation. Civilization has not yet destroyed in their minds the semblance of the great Parent of good.

Nature has done much for the inhabitants of Mount's Bay, by presenting to their senses all things that can awaken in the mind the emotions of greatness and sublimity. She has placed them far from cities, and given them forms of visible and audible beauty.

I am now reviving old associations, and endeavouring to attach old feelings to a few simple objects.

I am, &c.

H. DAVY.

Although the letter which follows is without date, I am unwilling to withhold it.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE,

I HAVE been for some weeks absent from London, and have only just received your letter. When I return in the winter, I shall be glad to see Mr. A.—I regret that your niece is so much indisposed. Lady Davy has been obliged to change her climate in consequence of a long-continued cough, but I am happy in being able to say she is now quite well.

After the fatigues of a long season in London, I am now enjoying the Highland scenery and sports with a purer pleasure, and I find, after the Alps and Pyrenees, even the mountains of Scotland possessing some peculiar beauties. You ought to come and see this country, which you would enjoy, both as a lover of nature and of man. The one is grand and beautiful; the other, moral, active, and independent. I am, my dear Poole,

Your obliged friend,

H. DAVY.

The Philosophical Transactions, during the Presidency of Sir Humphry Davy, evince the alacrity with which he redeemed the pledge given to the Society in his address on taking the chair—

"And though your good opinion has, as it were, honoured me with a rank similar to that of General, I shall be always happy to act as a private soldier in the ranks of Science."

Many years before even the identity of lightning and electricity was suspected, it had been observed, on several occasions, that the magnetism of the compass needle was not only destroyed, which might have been attributed to heat, but that it was even reversed by lightning.*

In the progress of electrical discoveries, the similarity between electricity and magnetism had not escaped observation, and some philosophers had even attempted to establish the existence of an identity or intimate relation between these two forces. The experiments of Ritter, however, alone appeared to offer any confirmation of the supposed analogy; but so obscure was his lan-

* Davy observes, that there are many facts recorded in the Philosophical Transactions, which prove the magnetising powers of lightning: one in particular, where a stroke of lightning passing through a box of knives, rendered most of them powerful magnets. *Philosophical Transactions*, No. 157, p. 520, and No. 437, p. 57.

guage, and so wild and hypothetical his views, that few, if any, of them were repeated either in France or England, and their results were for a long time wholly disregarded.

In a work, entitled "Recherches sur l'identité des Forces Chimiques et Electriques," published by M. Oersted in the year 1807, the subject was resumed, and the author advanced the hypothesis,* which twelve years afterwards conducted him to one of the most important discoveries of the present age, and which has given origin to a new science, termed ELECTRO-MAGNETISM.

In the winter of 1819, Professor Oersted, Secretary to the Royal Society of Copenhagen, published on account of some experiments, in which the electric current, such as is supposed to pass from the positive to the negative pole of a Voltaic battery, along a wire which connects them, caused a magnetic needle near it to deviate from its natural position, and to assume a new one, the direction of which was observed to depend upon the relative position of the needle and the wire.†

It may be necessary to premise, that these experiments were conducted in a form which had never before suggested itself to the enquirer; *viz. with the two ends of the pile in communication with each other:* a circumstance which will, at once, explain the reason of all preceding failures. It was never before suspected that the electric current, passing *uninterruptedly* through a wire, connecting the two ends of a Voltaic battery, was capable of being manifested by any effect; the experiments, however, in question furnished an unequivocal test of its passage by its action on the magnetic needle; and which may be shortly stated as follows:

The opposite poles of a battery, in full action, were joined by a metallic wire, which, to avoid circumlocution, has been called the *uniting conductor*, or the *uniting wire.*

* The hypothesis was this:—"In galvanism, the force is more *latent* than in electricity, and still more so in magnetism than in galvanism; it is therefore necessary to try whether electricity, in its *latent* state, will not affect the needle." This passage may be thus explained: When the Voltaic circuit is interrupted, it possesses opposite electrical poles; and when continuous, it no longer affects the electrometer, or the electricity becomes *latent*, which is the condition theoretically required for the manifestation of its magnetic action: and the fundamental experiment of Oersted proved that, under these circumstances, the compass needle was affected.

† For this discovery, the President and Council of the Royal Society adjudged to M. Oersted the medal on Sir Godfrey Copley's Donation, for the year 1820.

On placing the wire above the magnet and parallel to it, the pole next the negative end of the battery always moved westward, and when the wire was placed under the needle, the same pole went towards the east. If the wire was on the same horizontal plane with the needle, no declination whatever took place, but the magnet showed a disposition to move in a vertical direction; the pole next the negative side of the battery being depressed when the wire was to the west of it, and elevated when it was placed on the east side.

The extent of the declination occasioned by a battery, depends upon its power, and the distance of the uniting wire from the needle. If the apparatus is powerful, and the distance small, the declination will amount to an angle of forty-five degrees or more; but this deviation does not give an exact idea of the real effect which may be produced by galvanism; for the motion of the needle is counteracted by the magnetism of the Earth. When the influence of this latter power is destroyed by means of another magnet, the needle will place itself directly across the connecting wire: so that the real tendency of a magnet is to stand at right angles to an electric current. Such phenomena, being wholly at variance with the laws of simple electrical attraction and repulsion, are only to be explained upon the supposition that a new energy is generated by the action of the current of electricity thus brought into conflict, and which must be identical with, or nearly related to, magnetism.

It would also appear from the motions of the magnet, when differently placed with regard to the *uniting wire*, that this energy circulates, or performs a circular movement around the axis of the conductor, and thus drives the magnetic pole according to the direction of the needle with reference to such a current.

This important discovery was no sooner announced to the philosophical world, than Sir Humphry Davy, with his characteristic zeal, proceeded to repeat the experiments; and, with his usual sagacity, so to vary and extend them, as to throw new light upon this novel department of science. The facts he thus discovered, and the reasonings founded upon them, were communicated by him to the Royal Society in three successive memoirs.

The First, " On the Magnetic Phenomena produced by Electricity," was read on the 16th of November 1820.

The Second, entitled " Farther Researches on the Magnetic Phenomena produced by Electricity; with some new Experiments on the properties of Electrified bodies, in their relations to conducting powers and Temperature," read July 5th, 1821.

The Third, "On a new Phenomenon of Electro-magnetism," read March 6th, 1823.

The principal experiments communicated in these memoirs were performed with the battery belonging to the London Institution,* the once powerful apparatus at the Royal Institution having become old and feeble in his service.

The following letter contains an invitation to his friend Mr. Pepys, to witness his first experiment; a document so far valuable, as it fixes a date of some importance in the history of discovery.

TO WILLIAM HASLEDINE PEPYS, ESQ.

DEAR PEPYS, Grosvenor Street, October 20, 1820.

The experiment I wish to show you is no less than the conversion of electricity into magnetism ; but it is a secret as yet.

I will come to you at twelve on Monday, in the Poultry. If you will be so good as to order the battery to be charged to-morrow, it will be ready for us on Monday.

Have you a dipping needle? This, and an air-pump, and the globe for taking sparks *in vacuo* by points of charcoal, are all we shall want.

Perhaps you will invite Dr. Babington, and our worthy friend Allen.

I will show you the opening of quite a new field of experiment.

Ever yours very sincerely,

H. Davy.

The discovery of Professor Oersted was limited to the action of the electric current on needles previously magnetised. Davy ascertained that the *uniting conductor itself became magnetic*, during the passage of the electricity through it.† It was in consequence of having observed some anomaly, with

* I find from a note addressed to Mr. Pepys, that on the 21st of June 1822, Davy worked the two batteries of 1000 plates each at the London Institution, before the Prince Royal of Denmark. The experiments were principally electro-magnetic.

† It would appear that M. Arago likewise discovered this fact at about the same period; but it is evident that the French and English philosophers arrived at the result independently of each other; for the experiments which led to it were made by Sir H. Davy in October 1820; while the September number of the "Annales de Physique," containing the first account of the Researches of M. Arago, was not received in London until the 24th of November in that year; and it may be farther observed, that the numbers of this journal were very commonly published several months after the affixed date.

respect to the way in which the uniting wire altered the direction of the magnet, that he was led to a conjecture which he immediately verified by a very simple experiment. He threw some iron filings on a paper, and brought them near the uniting wire, when immediately they were attracted by the wire, and adhered to it in considerable quantities, forming a mass round it ten or twelve times the thickness of the wire: on breaking the communication, they instantly fell off, proving that the magnetic effect entirely depended upon the passage of electricity through the wire.

Davy observes, it was easy to imagine that such magnetic effects could not be exhibited by the electrical wire, without its being capable of permanently communicating them to steel; and that, in order to ascertain whether such was the fact, he fastened several steel needles, in different directions, to the uniting wire, when those parallel to it were found to act like the wire itself, while each of those placed across it acquired two poles. Such as were placed *under* the wire, the positive end of the battery being east, had north poles on the south of the wire, and south poles to the north. The needles *above* were in the opposite direction; and this was constantly the case, whatever might be the inclination of the needle to the wire. On breaking the connexion, the steel needles, placed *across* the uniting wire, retained their magnetism,* while those placed *parallel* to it lost it at the moment of disunion. The most extraordinary circumstances, however, connected with these experiments were, first, that *contact* with the uniting wire was not found necessary for the production of the effect,—indeed, it was even produced, though thick glass intervened; and, secondly, that a needle which had been placed in a transverse direction to the wire, merely for an instant, was found as powerful a magnet as one that had been long in communication with it.

* M. Arago also, nearly at the same time, succeeded in communicating magnetism to the needle; but, at the suggestion of M. Ampère, it was effected in a different manner. A copper wire, by being rolled round a solid rod, was twisted into a spiral, so as to form a *helix*. It was easy, by passing the wire round the rod, in one direction or the other, to form a *dextrorsal* helix, proceeding from the right hand towards the left, as in the tendrils of many plants; or a *sinistrorsal*, or left helix, proceeding downwards from the left hand to the right above the axis. Into the cavity of a spiral thus formed, connecting the two poles of a battery, a steel needle wrapped in paper was introduced; and, in order to exclude all influence of the magnetism of the earth, the conchoidal part of the wire was kept constantly perpendicular to the magnetic meridian. In a few minutes, the needle had acquired a sufficiently strong dose of magnetism; and the position of the north and south poles exactly agreed with M. Ampère's notion, that the electric current traverses the connecting wire in a direction from the zinc extremity of the pile to the copper extremity.

The distance to which magnetism is communicated by electricity, and the fact of its taking place equally through conductors and non-conductors, are circumstances which, in the opinion of Davy, are unfavourable to the idea of the identity of electricity and magnetism.

Davy subsequently ascertained by experiment, that the magnetic result was proportional to the quantity of electricity passing through a given space; and this fact led him to believe, that a wire electrified by the common machine would not occasion á sensible effect; and this he found to be the case, on placing very small needles across a fine wire connected with a prime conductor of a powerful machine and the earth. But as a momentary exposure in a powerful electrical circuit was sufficient to give permanent polarity to steel, it appeared equally obvious, that needles placed transversely to a wire at the time that the electricity of a common Leyden battery was discharged through it, ought to become magnetic; and this he found was actually the fact, and according to precisely the same laws as in the Voltaic circuit; the needle *under* the wire, the positive conductor being on the right hand, offering its north pole to the face of the operator, and the needle *above*, exhibiting the opposite polarity.

The facility with which experiments are made with the common Leyden battery enabled him to ascertain various other important facts, respecting the communication of magnetism, which it would be inconsistent with the nature and limits of this work to particularize. I have merely offered a notice of the more prominent discoveries communicated by him in his first paper to the Royal Society, and which he concludes by observing, that "in consequence of the facts lately developed, a number of curious speculations cannot fail to present themselves to every philosophical mind; such as whether the magnetism of the earth may not be owing to its electricity, and the variation of the needle to the alterations in the electrical currents of the earth, in consequence of its motions, internal changes, or its relations to solar heat; and whether the luminous effects of the auroras at the poles are not shown, by these new facts, to depend on electricity. This is evident, that if strong electrical currents be supposed to follow the apparent course of the sun, the magnetism of the earth ought to be such as it is found to be." *

* A very ingenious piece of apparatus was contrived to illustrate this theory by experiment; but I am uncertain as to whom the credit of it belongs. It consisted of a globe, containing metallic wires, arranged in relation to each other according to the electro-magnetic theory, when, by passing an electric current in the direction of the ecliptic, the poles became magnetic.

Davy never overlooked an occasion of applying theory to practice, and he therefore proposes, upon the principles developed in this paper, to make powerful magnets, by fixing bars of steel, or circular pieces of steel, fitted for making horse-shoe magnets, round the electrical conductors of buildings in elevated and exposed situations.

His second paper contains an account of experiments instituted with a view to gain some distinct knowledge on the subject of the relations of the different conductors to the magnetism produced by electricity. The results were decisive; but, without entering minutely into the theory of the subject which they so ably illustrated, these experiments cannot be clearly described, or successfully explained. The same observation will apply to the researches detailed in his third paper, announcing the discovery of a *new electro-magnetic phenomenon;* for, since they are inseparably connected with Mr. Faraday's beautiful experiments on *Magnetic Rotation,* I could scarcely expect to render my analysis of the memoir sufficiently intelligible, without entering at length upon that curious subject; I am unwilling, however, to refer the reader to the original paper in the Transactions, without offering a remark upon the *phenomenon,* which he says "is the *principal* object of the paper," but which we might conclude, from the hasty and imperfect manner in which he dismisses it, to have occupied a very subordinate place in his estimation. In his anxiety to examine and describe the rotations produced during this experiment, he bestows far too little attention upon the more, indeed I might say the *only,* important phenomenon of the cone of mercury which was elevated above each of the wires proceeding from the battery; and which, arising as it evidently did from a repulsive influence, clearly shows that the presence of electricity establishes between the particles of matter a repulsive energy, whether that matter be conducting, or non-conducting in its functions. This law, M. Ampère subsequently illustrated by a different form of experiment, and unfairly, as I must think, omitted even to notice Davy's prior result.

On the 20th of December 1821, Davy communicated to the Royal Society a memoir "On the Electrical Phenomena exhibited *in vacuo.*"

It had been stated by Mr. Walsh, and the opinion had been subsequently supported by the researches of Mr. Morgan, that the electrical light was not producible in a perfect Torricellian vacuum; the latter gentleman also concluded that such a vacuum prevented the charging of coated glass.

An enquiry of greater importance can scarcely be imagined; involving in its train several of the most abstruse and difficult questions of corpuscular philosophy ; as, whether electricity be a subtile fluid, or electrical effect the mere exhibition of the attractive powers of the particles of bodies ; for, if it can be shown that these effects take place in a perfect vacuum, we shall advance towards the conclusion, that electrical phenomena depend upon the agency of an ethereal and transcendental fluid. It was under such an impression that Davy proceeded to determine, if possible, " the relations of electricity to space, as nearly void of matter as it can be made on the surface of the earth."

He was, in the first instance, led to suspect the accuracy of those conclusions at which Mr. Walsh and Mr. Morgan had arrived, from considering that, " in the most perfect vacuum which can be obtained in the Torricellian tube, vapour of mercury, though of extremely small density, must still always exist." I propose to follow our philosopher through the paths of this enquiry ; and then, with all the deference due to such high authority, to state the objections which may be urged against his results.

First, then, as to the results he obtained with quicksilver in an apparatus simple, but well adapted at once to insure the most completely attainable vacuum, and to exhibit its capability of receiving a charge. In all cases where this vacuum was perfect, he found it to be permeable to electricity, and to be rendered luminous, either by the common spark, or by the shock from a Leyden jar ; and, moreover, that the coated glass surrounding it became charged under such circumstances ; but the intensity of the light in these experiments was always in proportion to the temperature, or, in other words, to the density of the mercurial vapour ; and that at 20° below zero of Fahrenheit, it became so faint as to require considerable darkness to render it perceptible.

The great brilliancy, on the other hand, of the electrical light in pure, dense vapour of mercury, was beautifully displayed during the operation of boiling the metal in an exhausted tube. " In the formation and condensation of the globules of mercurial vapour, the electricity produced by the friction of the mercury against the glass, was discharged through the vapour with sparks so bright as to be visible in daylight."

The charge likewise communicated to the tin-foil was higher, the higher the temperature ; at 0° Fahrenheit it was extremely feeble. This, like the phenomenon of the electric light, must, he thinks, depend upon the different density of the vapour of mercury.

But he was desirous of still farther refining his experiments, so as to exclude, as far as it was possible, the presence of any volatile matter ; and, in this part of the enquiry he displayed, in a very masterly manner, that happy talent, in which he so far surpassed his contemporaries, of suggesting expedients and contriving new apparatus in order to vanquish practical difficulties.

To get rid of a portion of mercurial vapour, he employed a difficultly fusible amalgam of mercury and tin, which was made to crystallize by cooling in the tube; but, in this case, the results were precisely the same as when pure mercury had been used. He then attempted to make a vacuum above the fusible alloy of bismuth, but he found it so liable to oxidate and soil the tube, that he soon renounced farther attempts of this kind. Nothing discouraged, he determined to try the effects of a comparatively fixed metal in fusion. By melting freshly-cut pieces of grain tin, in a tube made void after having been filled with hydrogen, and by long-continued heat and agitation, he obtained a column of fixed metal which appeared to be entirely free from gas; and yet the vacuum made above this exhibited the same phenomena as the mercurial vacuum, except that they were not perceptibly increased by heat: a fact which Davy must have anticipated, as he attributed the greater display of electrical light, at high temperatures, to the effect of increased density of vapour; it is therefore a matter of surprise that he did not give more importance to the phenomenon.

He made two experiments on electrical and magnetic repulsions and attractions in the mercurial vacuum, and he found that two balls, the one of platinum, the other of steel, properly arranged for the purpose, repelled each other, when the conducting wire to which they were attached was electrified in the most perfect mercurial vacuum, as they would have done in the usual cases: and that the steel globules were as obedient to the magnet as in the air; which last result, he observes, it was easy to have anticipated.

He also made some comparative experiments, with the view of ascertaining, whether below the freezing point of water the diminution of the temperature of the Torricellian vacuum diminished its power of transmitting electricity, or of being rendered luminous by it. To about twenty degrees, this appeared to be the case; but between twenty degrees above, and twenty degrees below zero, the lowest temperature he could produce by pounded ice and muriate of lime, it seemed stationary; and, as well as he could determine, the electrical phenomena were very nearly of the same intensity as those produced in the vacuum above tin.

"It is evident," he says, "from these general results, that the light (and probably the heat) generated in electrical discharges depends *principally* on some properties or substances belonging to the ponderable matter through which it passes: but they prove likewise that space, where there is no appreciable quantity of this matter, is still capable of exhibiting electric phenomena—viz. those of attraction and repulsion, &c.: a fact unquestionably favourable to the idea of the phenomena of electricity being produced by a highly subtile fluid or fluids, of which the particles are repulsive with respect to each other, and attractive of the particles of other matter.

However much we may admire the experimental address displayed in this paper, we must confess that its results are very far from being satisfactory. His having assumed, without proof, and even without examination, the theory that a perfect vacuum cannot be produced in the Torricellian tube, and made it the foundation of his reasonings, appears to me to have vitiated all his conclusions. Mr. Faraday has rendered it extremely probable, that a *limit* does actually exist to the production of vapour by bodies placed *in vacuo*,* beneath which they are perfectly fixed; and if this be true, it is evident that, at low temperatures, a perfect vacuum may be produced in the Torricellian tube; and it is highly probable that Davy did thus actually produce one in several of his experiments; especially in those where he found that, by a farther reduction of temperature, no farther diminution of electrical effect was perceptible: he had in fact arrived at this limit to vaporization, and therefore a farther reduction of temperature could not possibly influence the phenomena. In this point of view, the electrical light would seem to be *primary*, or independent of foreign matter.—But though the premises be granted, let the reader pause before he hastens to any conclusion; for the cloud of mystery has not been dissipated, it has only changed its place. At the termination of his paper, Davy indulges in a conjecture subversive of every conclusion deduced from experiments *in vacuo*. "When the intense heat," says he, "produced by electricity, and the strong attractive powers of differently electrified surfaces, and the rapidity of the changes of state, are considered, it does not seem at all improbable, that the superficial particles of bodies, which, when detached by the repulsive power of heat, form vapour, may be likewise detached by electrical powers, and that they may produce luminous appearances in a vacuum free from all other matter, by the annihilation of their opposite electrical states."

During the course of the enquiry, Davy is led to suppose that air may

* "On the Existence of a Limit to Vaporization. By M. Faraday, F.R.S. Corresponding Member of the Royal Academy of Sciences at Paris." Phil. Trans. 1826.

exist in mercury, in the same invisible state as it does in water, that is, distributed through its pores; and that absorption of air may, therefore, explain the difference of the heights of the mercury in different barometers. This, it must be confessed, if true, is a most disheartening fact, as it at once precludes the possibility of any thing like accuracy in our barometers; but Mr. Daniell, to whom on all subjects of meteorology we are bound to pay the greatest deference, differs altogether from our philosopher upon this point, and he adduces a single observation which he thinks nearly disproves the supposition. "All fluids," says he, "which are known to absorb air into their pores, invariably emit it when the pressure of the atmosphere is removed; but, upon an extensive examination of large bodies of mercury, variously heated in the vacuum of an air-pump, I never saw a bubble of air given off from the surface of the metal." Davy, it must be stated, obtained a far different result; but an observation of Mr. Daniell explains the cause of it. "Air," he continues, "will rise from the contact of the mercury with the glass in which it is contained, in exact inverse proportion to the care with which it has been filled, but it *never rises from the surface of the mercury alone.* The difficulty of properly filling a barometer tube, I attribute to the attraction between the glass and the air—not to that between the mercury and the air."*

On the 13th of June 1822, a memoir was read before the Royal Society, "On the state of Water and Aëriform matter in cavities found in certain Crystals. By Sir Humphry Davy, Bart. P. R. S."

It is generally admitted by Geologists, that the greater number of the crystalline substances of the mineral kingdom must have been previously in a liquid state; but different schools have assumed different causes for their solution; some attributing the effect principally to the agency of water, others to that of heat.

In the paper under consideration, the author very freely avows himself as the champion of the latter doctrine.

"When it is considered," says he, "that the solvent power of water depends upon its temperature, and its deposition of solid matters upon its change of state or of temperature, and that, being a gravitating substance, the same quantity must always belong to the globe, it becomes difficult to allow

* "Meteorological Essays and Observations," p. 363.—See also Bellani's experiments upon this subject, which are so satisfactory as to remove every doubt from the subject.

much weight to the arguments of the Wernerians, or Neptunists, who have generally neglected, in their speculations, the laws of chemical attraction.

"There are many circumstances, on the contrary, favourable to that part of the views of the Huttonians, or Plutonists, relating to the cause of crystallization; such as the form of the earth, that of an oblate spheroid flattened at the poles; the facility with which heat, being a radiating substance, may be lost and dissipated in free space; and the observations which seem to show the present existence of a high temperature in the interior of the globe."

He had often, he tells us, in the course of his chemical researches, looked for facts, or experiments, which might throw some light on this interesting subject, but without success, till it occurred to him, as he was considering the state of the fluid and aëriform matters which are found included in certain crystals, that these curious phenomena might be examined in a manner to afford some important arguments as to the formation of the crystal itself.

Having obtained, through the liberality of his friends, a variety of appropriate specimens of rock-crystal, he proceeded to submit them to experiment. Their cavities were opened by means of diamond drills, under either distilled water, oil, or mercury; the gas was then expelled from them by the introduction of slender wires, and the included fluids were drawn out by the aid of fine capillary tubes.

As soon as an opening was effected, the fluid under which the operation had been performed rushed into the cavity, and the globule of elastic fluid contracted so as to appear from six to ten times less than before the experiment. The fluid was found to be nearly pure water,—the gas appeared to be azote.

It was an interesting point to ascertain whether the same circumstances occurred in productions found in rocks which have been generally considered as of igneous origin, such as the basaltic rocks in the neighbourhood of Vicenza, the chalcedonies of which so often afford water. On examining such specimens, when, to obviate the possibility of any fallacy, they were previously ascertained to be impermeable to the atmosphere, analogous results were obtained: water, containing very minute quantities of saline impregnations, was found to be the fluid, and the gas, as in the former instances, was ascertained to be azote; but it was in a much more rarefied state than in the rock-crystals, being between sixty and seventy times as rare as atmospheric air.

The fact of azote being found in these cavities, he explains, by supposing that atmospheric air might have been originally included in the crystals, and that the oxygen had been separated from it by the attraction of the water; a conjecture which a direct experiment appeared to confirm.

In reasoning upon the vacuum, or rarefied state of the aëriform matter in the cavities of rock-crystals and chalcedonies, he very justly states, that the phenomenon cannot be easily accounted for, except on the supposition of their having been formed at a higher temperature than that now belonging to the surface of the globe: and he thinks it most probable that the water and the silica were in chemical union, and separated from each other by cooling, since there are strong grounds for believing that a liquid *hydrate of silica* would exist at high temperatures under pressure, and that, like all liquid bodies in the atmosphere, it would contain small quantities of atmospheric air. If this be granted, we may readily explain the phenomena presented by the gaseous and liquid matters in rock-crystal and chalcedony.

Thus then did Davy assail the Neptunists in their own camp, and vanquish them with their own weapons; for the fact, which had been confidently considered by the disciples of Werner, as, above all others, hostile to the idea of the igneous origin of crystalline rocks, namely, the existence of water in them, has been made to afford a decisive argument in favour of the very opinion it had been brought forward to oppose.*

In an appendix to the foregoing paper, the examination of two other crystals is detailed; the results afforded were very different from those of the preceding ones, but not less favourable to the theory of igneous origin. One of these crystals was found to contain a bituminous fluid; on piercing it under distilled water, the water rushed in, and entirely filled the cavity, so that no aeriform matter but the vapour of the substance could have been present. The fact of almost a perfect vacuum existing in a cavity containing an expansible but difficultly volatile substance, must be considered as highly favourable to the theory of the igneous origin of crystals.

In the other crystal, the quantity of aëriform matter was unusually small in proportion to the quantity of fluid, and from the peculiarity of its motion, it appeared to be more likely to be compressed than rarefied elastic fluid; and

* I well remember with what triumph the late Dr. Clarke, in his popular lectures on Mineralogy at Cambridge, paraded a fine crystal containing water in its cavity. "Gentlemen," said he, "there is water enough in the very crystals in my cabinet to extinguish all the fires of the Plutonists."

in piercing the sides of the cavities, Davy found that this was the case; it enlarged in volume from ten to twelve times; the fluid was water, but the gas was too minute in quantity to be examined. There is but one mode of accounting for this phenomenon. The crystal must have been formed under an immense weight of atmosphere or fluid, sufficient to produce a compression much more than adequate to compensate for the expansive effects of heat.*

* An explanation which the experiments of Mr. Faraday, on the condensation of the gases, to be immediately described, will most fully justify.

CHAPTER XIII.

The Liquefaction of Chlorine Gas first effected by Mr. Faraday, and witnessed by the Author.—Sir H. Davy continues the investigation.—His paper on the application of liquefiable Gases as mechanical agents.—Other probable uses of these bodies.—He proposes several methods to prevent the fumes which arise from Smelting Furnaces.—Importance of the subject.—His Letters to Mr. Vivian.—The Government solicit the advice of the Royal Society on the subject of protecting the Copper Sheathing of Ships from the action of sea water.—Sir H. Davy charges himself with this enquiry.—He proposes a plan of protection founded on Voltaic principles.—His numerous experiments.—He embarks on board the Comet steam-vessel bound to Heligoland, in order to try his plan on a vessel in motion.—He arrives at Mandal, lands, and fishes in the lakes.—The Protectors washed away.—He teaches the inhabitants of Christiansand to crimp fish.—He remains a few days at Arendal.—A Norwegian dinner.—The Protectors are examined and weighed.—Results of the experiment.—The steam-vessel proceeds up the Glommen.—He visits the great waterfall.—Passes into Sweden.—Has an interview with the Crown Prince of Denmark, and afterwards with Prince Christian at Copenhagen.—He visits Professor Oersted.—He proceeds to Bremen to see Dr. Olbers.—Returns to England.—His third paper read before the Royal Society.—Voltaic influence of patches of rust.—A small quantity of fluid sufficient to complete the circuit.—He receives from the Royal Society the Royal Medal.—The Progress of Voltaic discovery reviewed.—The principle is of extensive application.—The Author's researches into the cause of the solution of Lead in spring water.—An account of the numerous trials of Protectors. —Failure of the plan.—Report of the French on the state of the protected frigate, La Constance. —Dr. Riviere's new plan of Protection.

Every incident, however trifling, if it relates to a great scientific discovery, merits the attention of the historian. As it accidentally occurred to me, and to me alone, to witness the original experiment by which Mr. Faraday first condensed chlorine gas into a liquid, I shall here state the circumstances under which its liquefaction was effected.

I had been invited to dine with Sir Humphry Davy, on Wednesday the 5th of March 1823, for the purpose of meeting the Reverend Uriah Tonkin, the heir of his early friend and benefactor of that name.* On quitting my house for that purpose, I perceived that I had time to spare, and I accordingly called in my way at the Royal Institution. Upon descending into the laboratory, I found Mr. Faraday engaged in experiments on chlorine and its hydrate in closed tubes. It appeared to me that the tube in which he was operating upon this substance, contained some oily matter, and I rallied him upon the carelessness of employing soiled vessels. Mr. Faraday, upon inspecting the tube, acknowledged the justness of my remark, and expressed his surprise at the circumstance. In consequence of which, he immediately proceeded to file off the sealed end, when, to our great astonishment, the contents suddenly exploded, and the oily matter vanished!

Mr. Faraday was completely at a loss to explain the occurrence, and proceeded to repeat the experiment with a view to its elucidation. I was unable, however, to remain and witness the result.

Upon mentioning the circumstance to Sir Humphry Davy after dinner, he appeared much surprised; and after a few moments of apparent abstraction, he said, " I shall enquire about this experiment to-morrow."

Early on the next morning, I received from Mr. Faraday the following laconic note:

DEAR SIR,

THE *oil* you noticed yesterday turns out to be liquid chlorine.

Yours faithfully,

M. FARADAY.

It is well known that, before the year 1810, the solid substance obtained by exposing chlorine, as usually procured, to a low temperature, was considered as the gas itself reduced into that form; Sir Humphry Davy, however, corrected this error, and first showed it to be a hydrate, the pure gas not being condensible even at a temperature of —40° Fahrenheit.

Mr. Faraday had taken advantage of the cold season to procure crystals of this hydrate, and was proceeding in its analysis,† when Sir Humphry Davy

* Sir Humphry had expressed to me, on the preceding Thursday at the Royal Society, his wish to purchase the old house in Penzance, which, as the reader will remember, was the early scene of his chemical operations; and, at his request, I conversed with Mr. Tonkin upon the subject; but it immediately appeared, that the interest which the Corporation of Penzance possessed in the estate, presented an insurmountable obstacle to the accomplishment of his object.

† The results are contained in a short paper in the Quarterly Journal of Science, vol. xv.

suggested to him the expediency of observing what would happen if it were heated in a close vessel; but this suggestion was made in consequence of the inspection of results already obtained by Mr. Faraday, and which must have led him to the experiment in question, had he never communicated with Sir Humphry Davy upon the subject. This avowal is honestly due to Mr. Faraday.

On exposing the hydrate, in a tube hermetically sealed, to a temperature of 100°, the substance fused, the tube became filled with a bright yellow atmosphere, and, on examination, was found to contain two fluid substances: the one, about three-fourths of the whole, was of a faint yellow colour, having very much the appearance of water; the remaining fourth was a heavy, bright yellow fluid, lying at the bottom of the former, without any apparent tendency to mix with it.

By operating on the hydrate in a bent tube hermetically sealed, Mr. Faraday found it easy, after decomposing it by a heat of 100°, to distil the yellow fluid to one end of the tube, and thus to separate it from the remaining portion. If the tube were now cut in the middle, the parts flew asunder, as if with an explosion, the whole of the yellow portion disappeared, and there was a powerful atmosphere of chlorine produced; the pale portion, on the contrary, remained, and, when examined, proved to be a weak solution of chlorine in water, with a little muriatic acid, probably from the impurity of the hydrate used. When that end of the tube in which the yellow fluid lay was broken under a jar of water, there was an immediate production of chlorine gas.

After several conjectures as to the nature of the changes thus produced, Mr. Faraday arrived at its true explanation; viz. that the chlorine had been entirely separated from the water by the heat, and condensed into a dry fluid by the mere pressure of its own abundant vapour. He subsequently confirmed these views by condensing chlorine in a long tube, by mechanical pressure, applied by means of a condensing syringe, and which farther enabled him to ascertain that the degree of pressure necessary for this effect was about that of four atmospheres.

To Mr. Faraday's paper upon this subject, published in the Philosophical Transactions for the year 1823, Sir Humphry Davy thought proper to add a "Note on the condensation of muriatic acid gas into the liquid form."

The circumstances under which this was effected are briefly these. On the morning (Thursday, March 6th,) after Mr. Faraday had condensed chlorine, Sir Humphry Davy had no sooner witnessed the result, than he called for a strong glass tube, and, having placed in it a quantity of muriate of ammonia and sulphuric acid, and then sealed the end, he caused them to act upon each other, and thus condensed the muriatic acid, which was evolved, into a liquid. The condensation of carbonic acid gas, nitrous oxide gas, and several others, were in succession treated with similar success; but, as I regard the discovery as strictly belonging to Mr. Faraday, I shall confine myself to the relation of those experiments and deductions which, with equal justice, I must assign to Sir Humphry Davy.

He observes, "that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating their molecules than those dependent upon the application of cold, whether natural or artificial: for, as gases diminish only about $\frac{1}{480}$ in volume for every — degree of Fahrenheit's scale, beginning at ordinary temperatures, a very slight condensation only can be produced by the most powerful freezing mixtures, not half as much as would result from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature: and when attempts are made to condense gases into liquids by sudden mechanical compression, the heat, instantly generated, presents a formidable obstacle to the success of the experiment; whereas, in the compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger; and it may be easily assisted by artificial cold in cases when gases approach near to that point of compression and temperature at which they become vapours."

On the 17th of April 1823, he communicated to the Royal Society a paper "On the application of Liquids formed by the condensation of Gases as mechanical agents."

He states that doubts may, for various philosophical reasons, exist as to the economical results to be obtained by employing the steam of water under great pressures, and at very elevated temperatures; but that no doubts can arise with respect to the use of such liquids as require for their existence even a compression equal to that of the weight of thirty or forty atmospheres; and where common temperatures, or slight elevations of them, are sufficient to produce an immense elastic force; and when the principal question to be discussed is, whether the effect of mechanical motion is to be most easily produced by an increase or diminution of heat by artificial means.

With the assistance of Mr. Faraday, he made several experiments on the differences between the increase of elastic force in gases under high and low pressures, by similar increments of temperature. In an experiment made with carbonic acid, its force was found to be nearly equal to that of air compressed to one-twentieth at 12° Fah. and of air compressed to one-thirty-sixth at 32 degrees, making an increase equal to the weight of thirteen atmospheres by an increase of twenty of temperature!

In applying, however, the condensed gases as mechanical agents, Davy admits that there will be some difficulty; "the materials of the apparatus must be as strong and as perfectly joined as those used by Mr. Perkins in his high-pressure steam-engine: but the small differences of temperature to produce an elastic force equal to the pressure of many atmospheres, will render the risk of explosion extremely small;" and he adds, "that if future experiments should realize the views here developed, the mere difference of temperature between sunshine and shade, and air and water, or the effects of evaporation from a moist surface, will be sufficient to produce results, which have hitherto been obtained only by a great expenditure of fuel."

If this be true, who can say that future generations shall not perform their voyages in *gas*-vessels, across the Atlantic Ocean, with no other fuel than that which a common taper may supply? I fear, however, that in this scientific reverie, Davy merely looked at the difference of the sensible temperatures, and entirely neglected, in his calculation, the quantity of heat rendered latent during the change of the liquid into the gaseous state; and which, perhaps, is far more considerable in the application of these fluids than in that of water; but even in this latter case, the great expenditure of heat in working the steam-engine, is in the portion rendered latent, and which cannot, by any contrivance, be brought again into operation, after it has performed its duty. That a philosopher who had, during the whole progress of his researches, directed such unremitting attention to the subject of Heat, should have wholly overlooked an objection arising out of one of its most familiar phenomena, is scarcely less extraordinary than his having, on another occasion,* advanced to a conclusion in direct opposition to the very principle of Electricity, which his own discoveries had established.

* I here allude to an anecdote related by Mr. Babbage, in his "Reflections on the Decline of Science in England;" a work, by the by, which strongly reminds me of a practical bull. A gentleman, anxious to escape the tax on armorial bearings, wrote a long letter to the Commissioners, stating I do not know how many reasons to show that he could never have used them; and, after all,

Davy succeeded in liquefying gases by a method which, at first view, appears very paradoxical—*by the application of heat!* The method consists in placing them in one leg of a bent sealed tube, confined by mercury, and applying heat to ether, or alcohol, or water, in the other end. In this manner, by the pressure of the vapour of ether, he liquefied prussic gas and sulphurous acid gas; which gases, on being reproduced, occasioned cold.

There can be little doubt, he thinks, that these general facts of the condensation of the gases will have many practical applications. They offer, for instance, easy methods of impregnating liquids with carbonic acid and other gases, without mechanical pressure. They afford means of producing great diminutions of temperature, by the rapidity with which large quantities of liquids may be rendered aëriform; and as compression occasions similar effects to cold, in preventing the formation of elastic substances, there is great reason to believe that it may be successfully employed for the preservation of animal and vegetable substances for the purposes of food.

Davy might also have added, that the same general views will explain natural and other phenomena not previously understood. They certainly afford a plausible explanation of the nature of *blowers* in coal-mines; and they may lead to

sealed the letter with his own coat of arms! Had Mr. Babbage hoped to convince the reader that Science was actually on the decline in this country, he should never have written a work which gives the lie to the title-page. Now for the anecdote.—" Meeting Dr. Wollaston one morning in the shop of a bookseller, I proposed this question: If two volumes of hydrogen and one of oxygen are mixed together in a vessel, and if by mechanical pressure they can be so condensed as to become of the same specific gravity of water, will the gases, under these circumstances, unite and form water? 'What do you think they will do?' said Dr. W. I replied, that I should rather expect they would unite. 'I see no reason to suppose it,' said he. I then enquired whether he thought the experiment worth making. He answered, that he did not, for that he should think it would certainly *not* succeed.

" A few days after, I proposed the same question to Sir Humphry Davy. He at once said, 'They will become water of course;' and on my enquiring whether he thought the experiment worth making, he observed that it was a good experiment, but one which it was hardly necessary to make, as it must succeed.

" These were off-hand answers, which it might perhaps be hardly fair to have recorded, had they been of persons of less eminent talent; and it adds to the curiosity of the circumstance to mention, that I believe Dr. Wollaston's reason for supposing no union would take place, arose from the nature of the electrical relations of the two gases remaining unchanged: an objection which did not weigh with the philosopher whose discoveries had given birth to it."

more satisfactory views on other subjects of geology. They assign a limit to the expansive force of gas under increasing pressure, and account for effects connected with the *blasting* of rocks, which would otherwise appear anomalous.*

It may be stated, greatly to the honour of Davy, that there never occurred any question of scientific interest or difficulty in which he did not cheerfully offer his advice and assistance. Few Presidents of the Royal Society have ever exerted their influence and talents with so much unaffected zeal for the promotion of scientific objects, and for the welfare of scientific men. In the year 1821, the Great Hafod copper-works, in the neighbourhood of Swansea, were indicted for a nuisance, in consequence of the alleged destructive effects of the fumes which arose during the smelting of the ores. When we learn that the amount of wages paid by the proprietors of the works in this district exceeds 50,000*l.* per annum; that twelve thousand persons, at least, derive their support from the smelting establishments; that a sum of not less than 200,000*l.* sterling is annually circulated in Glamorganshire and the adjoining county, in consequence of their existence; that they pay to the collieries no less than from 100,000*l.* to 110,000*l.* per annum for coal; that one hundred and fifty vessels are employed in the conveyance of ore, and, supposing each upon an average to be manned by five seamen, that they give occupation to seven hundred and fifty mariners, a more serious calamity can be scarcely imagined than the stoppage of such works; we may therefore readily believe, that Davy entered most ardently into the consideration of some plan by which the fumes might be prevented, and the alleged nuisance abated.

Through the kind attention of my friend Mr. Vivian, I am enabled to insert the following letters.

* In the year 1812, Mr. Babbage attempted to ascertain whether pressure would prevent decomposition; for this purpose, a hole about thirty inches deep, and two inches in diameter, was bored downward into a limestone rock, into which was then poured a quantity of strong muriatic acid, and a conical wooden plug, that had been previously soaked in tallow, was immediately driven hard into the mouth of the hole. It was expected either that the decomposition would be prevented, or that the gas developed would split the rock by its expansive force; but nothing happened. Now, it is most probable that a part of the carbonic acid had condensed into a liquid, and thus prevented that developement of power which Mr. Babbage had expected would have torn the rock asunder.

TO JOHN HENRY VIVIAN, ESQ.

MY DEAR SIR, London, Jan. 9, 1822.

As you expressed a wish that I should commit to writing those opinions which I mentioned in conversation, when I had the pleasure of visiting you at Marino, after inspecting your furnaces and witnessing your experiments on the smoke arising from them, I lose no time in complying with your desire.

It is evident that the copper ore cannot be properly calcined without a copious admission of air into the furnaces, which must cause the sulphurous acid gas formed in the calcination to be mixed with very large quantities of other elastic fluids, which presents great mechanical, as well as chemical difficulties to its condensation or decomposition.

To persons acquainted with chemistry, a number of modes of effecting these objects are known. Of condensation, for instance, by water, by the formation of sulphuric acid, by alkaline lixivia, by alkaline earths, &c. Of decomposition, by hydrogen, by charcoal, by hydro-carbonous substances, and by metals; but to most of these methods there are serious and insurmountable objections, depending upon the diluted state of the acid gas, and the expenses required.

To form sulphuric acid, or to decompose by charcoal or hydrogen, or to condense by alkaline lixivia, or by alkaline earths, from the nature of the works, and of the operations for which they were intended, I conceive impracticable except at an expense that could not be borne; and the only processes which remain to be discussed are those by hydro-carbonous substances, and by the action of water.

There can be no doubt that the gas may be decomposed by the action of heated hydro-carbonous gases from the distillation of coal; but for this purpose there must be a new construction of the furnaces, and more than double, probably triple, the quantity of fuel would be required, supposing even the Swansea coal to contain the common average of bitumen; and this method must be infinitely more expensive, and liable to many more objections than the one you have so ingeniously employed—absorption by water.

As water costs nothing, and as a supply is entirely in your power, the application of it offers comparatively few difficulties; and it has the great advantage of freeing the smoke from fluoric and arsenious compounds, which would not be perfectly effected by any other method.

The experiments of MM. Phillips and Faraday prove, that your shower baths have already entirely destroyed all the fluoric and arsenious fumes of the smoke, and by a *certain* quantity of water, the smoke may undoubtedly be entirely freed from sulphurous acid gas.

This, *your own* plan, is the one that I strongly recommend to you to proceed with, and, if necessary, to extend.

Perhaps you may find an additional shower bath near the colder part of the flue useful. I have no idea that steam passed into the hot part of the flue can be of the least service; but if passed out with the smoke through the stack, it may tend to convert such residual portion of sulphurous acid gas, exposed to fresh air, into sulphuric acid. Could you not likewise try a stream of *cold* water passing along the bottom of the horizontal flue?*

I do not think the advantages of your improvements can be fairly appreciated, till the effects of your smoke are determined by actual experiments and fair trials. Yours, &c.

H. DAVY.

TO THE SAME.

MY DEAR SIR, London, May 12, 1823.

I RETURN you my thanks for the copies you were so good as to send me of your work on the modes you have adopted for rendering copper smoke innoxious, &c. I have read it with very great pleasure, and I am sure there can be but one feeling, and that of strong admiration, at the exertions you have made, and the resources you have displayed, in subduing the principal evils of one of our most important national manufactures. I trust you will have no more trouble on this subject, and that it will only occur to you in an agreeable form, with the high approbation as well as grateful feelings of your neighbours; and that your example will be followed.

A Committee of the Royal Society has been formed for investigating the causes of the decay of copper sheeting in the Navy, as I mentioned to you. The Navy Board has sent us a number of specimens of copper in different stages of decay. We have our first meeting to examine them on Thursday,

* For the purpose of acting by its cooling power in condensing vapour, which would carry down sulphurous acid with it. It would likewise assist by direct absorption. H. D.

and I shall have much pleasure in communicating to you our results. I wish I could do it in person.

I am going into Hampshire on Sunday next to fish near Fordingbridge for a week, and to try the Avon and its tributary streams.

I was going to give you an account of some experiments which Mr. Faraday has made by my directions in generating gases in close vessels as liquids, but I find I have not time. I have already found an application of this discovery, which I hope will supersede *steam*, as a difference of a few degrees of temperature gives the elastic force of many atmospheres.

Hoping to see you soon, I am, with best respects to Mrs. Vivian, and love to the charming little Bessy,

My dear Sir, yours sincerely obliged,

H. Davy.

I proceed now to relate the history of an elaborate experimental enquiry, instituted for the purpose of ascertaining the chemical nature and causes of the well-known corrosive action of sea water upon metallic copper; in order, if possible, to obviate that serious evil in naval economy—the rapid decay of the copper sheathing on the bottoms of our ships. An investigation which Sir Humphry Davy commenced in the year 1823, and prosecuted with his characteristic zeal and happy talent during a considerable period; when, at length, paradoxical as it may appear, the truth of his theory was completely established by the failure of his remedy!

From the several original documents which have been placed at my disposal, and from the valuable communications and kind assistance of my friend Mr. Knowles, I trust I shall be enabled to offer to the scientific reader a more complete and circumstantial history of this admirable enquiry than has been hitherto presented to the public.

The results he produced are equally interesting and important, whether we contemplate them biographically, as indicative of the peculiar genius by which they were obtained; or, scientifically, in their connexion with the electro-chemical theory, to the farther developement and illustration of which they have so powerfully contributed; or, economically, as the probable means by which the hand of time may be averted, an increased durability imparted to rapidly perishable works of art, and monuments of human genius transmitted to posterity, in all their freshness, through a long succession of ages.

It is probable that, in the earliest period of naval architecture, some expedient * was practised, in order to protect ships' bottoms from the ravages of marine worms.† The use of metallic sheathing, however, is of ancient date. The galley supposed to have belonged to the Emperor Trajan, was sheathed with sheets of lead, which were fastened with copper nails.‡ The same metal was also used in the earlier periods of our naval history;§ and it is worthy of remark, that the circumstances which led to its disuse, were the rapid corrosion of the *rother irons*, (from the formation of a Voltaic circle,) and the accumulation of sea-weed.

In the year 1761, copper plates were first used as sheathing on the Alarm frigate, of thirty-two guns;|| a second underwent this operation in 1765, a third in 1770, four in 1776, nine in 1777; and, in the course of the three following years, the whole British navy was coppered, an event which may be considered as forming an important era in the naval annals of the country.

The expense attending the use of copper for this purpose, in consequence of its corrosion and decay by salt water, has always been felt as a serious objection to its use, and various suggestions have, from time to time, occurred, and numerous experiments been made, in the hope of obviating the evil,¶ but without any great degree of success.

* Mr. Knowles, in his "Inquiry into the Means which have been taken to preserve the British Navy," observes, that the first sheathing was probably the hides of animals covered with pitch, or with asphaltum, which led to the use of thin boards, having, in some cases, lime, and in others lime and hair, between them and the bottom of the ships.

† The worms infesting the timber of ships are—the *Teredo*, the *Lepisma*, and the *Pholas*. The first of these, however, which was imported from India, is by far the most destructive; and I am informed by Mr. Knowles, that it is more abundant at Plymouth than on any other part of the coast where there is a dock-yard; and although on the shores of England it is not of a very large size, yet it is a formidable enemy to the safety of those ships which have not a metallic sheathing to cover their bottoms. In the East Indies, and off the coast of Africa, the *Teredo* is of very large size; and holes have been bored by them in the timber of at least seven-eighths of an inch in diameter.

‡ Alberti Archeti.

§ In the year 1670, an Act of Parliament was passed, granting unto Sir Philip Howard and Francis Watson, Esq. the sole use of the manufacture of milled lead for sheathing ships; and, in the year 1691, twenty ships had been sheathed with lead, manufactured by them, and which was fastened with copper nails.—See *Knowles's Inquiry*.

|| The copper sheathing was removed from this ship in 1763, when all the iron was found to be much corroded, the pintles and braces nearly eaten through, and the false keel lost, from the decay of the keel staples and the bolt fastenings. Thus, in the very first coppered ship, the Voltaic effect, produced by the contact of copper and iron, was displayed in a very striking manner.

¶ An experiment was tried by painting or varnishing their inner surfaces, but the use of brown

The solution of the metal, however, has been found to vary in degree at different anchorages; at Sheerness, for instance, its rapidity is very great, in consequence of the copper being subjected to the alternate action of the sea, which flows in there from the British Channel, and to the flux of water down the two great rivers, the Thames and Medway, loaded, as they necessarily must be, with the products of animal and vegetable decomposition.

In order, if possible, to obtain a remedy for this evil, the naval departments of the Government requested, in the latter part of the year 1823, the advice of the President and Council of the Royal Society, as to the best mode of manufacturing copper sheets, or of preserving them, while in use, against the corrosive effects of oxidation.

Sir H. Davy charged himself with this enquiry; the results of which he communicated to the Royal Society, in three elaborate memoirs. The first was read on the 22nd of January 1824; the second on the 17th of June, in the same year; and the third, and concluding paper, on the 9th of June 1825.

A very general belief prevailed, that sea water had little or no action on *pure* copper, and that the rapid decay of that metal, on certain ships, was owing to its impurity. On submitting, however, various specimens of copper to the action of the sea water, Sir H. Davy came to a conclusion, in direct opposition to such an opinion;* and Mr. Knowles informed me, in a late conversation upon the subject, that the attempts to purify the metal, since the Government has manufactured its own copper sheathing, has been the cause of its more rapid decay. It will, however, presently appear, that the relative durability of the metallic sheets must also be influenced by cir-

paper which has been dipped in tar, and placed between the wood and copper, is now considered to be the best mode. A solution of Caoutchouc spread on paper was tried on the bottom of Sir W. Curtis's yacht, but, on examination, it was pronounced to be less efficacious than tarred paper.

* In two instances, the copper (from the Batavier and from the Plymouth yacht) which had remained perfect for twenty-seven years, was found to be alloyed. In the former one there was an alloy of one-three-hundredth part of zinc; and, in the latter, the same proportion of tin. On the other hand, in the case of the copper on the Tartar's bottom, which was nearly destroyed in four years, upon being submitted to chemical examination by Mr. Phillips, it was found to be very pure copper.

Alloys of copper have generally been found more durable than the unmixed metal; and various patents have been taken out for the fabrication of such compounds; but metallic sheets so composed have been found to be too hard and brittle, and not to admit of that flexibility which is necessary for their application to a curved surface; the consequence of which has been, that they have cracked upon the ship's bottom.

cumstances wholly independent of their quality, some of which are very probably, even in our present advanced state of chemical knowledge, not thoroughly understood.

Sir H. Davy, on entering upon the examination of this subject, very justly considered, that to ascertain the exact nature of the chemical changes which take place in sea water, by the agency of copper, ought to be the first step in the enquiry; for, unless the cause were thoroughly understood, how could the evil be remedied?

On keeping a polished piece of copper in contact with sea water, the following were the effects which successively presented themselves. In the course of two or three hours, the surface of the metal exhibited a yellow tarnish, and the water in which it was immersed, contracted a cloudiness, the hue of which was at first white, but gradually became green. In less than a day, a bluish-green precipitate appeared, and constantly continued to accumulate in the bottom of the vessel; at the same time, the surface of the copper corroded, appearing red in the water, and grass-green where it was in contact with air. Upon this grass-green matter carbonate of soda formed; and these changes continued until the water became much less saline. The green precipitate he ascertained to consist of an insoluble compound of copper, (which he thinks may be considered as a *hydrated sub-muriate,*) and hydrate of magnesia.*

According to his own views of the nature of chlorine, he immediately perceived that neither soda nor magnesia could appear in sea water by the action of a metal, unless in consequence of an absorption or transfer of oxygen, which in this case must either be derived from the atmosphere, or from the decomposition of water; his experiments determined that the former was the source which supplied it. By reasoning upon these phenomena, and applying for their explanation his electro-chemical theory, which had shown that chemical attractions may be exalted, modified, or destroyed, by changes in the electrical states of bodies, he was led to the discovery of a remedy for the corrosion of copper, by the very principle which enabled him, sixteen years before, to decompose the fixed alkalies.

When he considered that copper is but weakly positive in the electro-chemical scale, and that it can only act upon sea water when in a positive state, it immediately occurred to him that, if it could be rendered slightly negative,

* The Muriate of Magnesia is the most active salt in sea-water.

the corroding action of sea water upon it would be null. But how was this to be effected? At first, he thought of using a Voltaic battery; but this could hardly be applicable in practice. He next thought of the contact of zinc, tin, or iron; but he was prevented for some time from trying this, by the recollection that the copper in the Voltaic battery, as well as the zinc, was dissolved by the action of dilute nitric acid; and by the fear, that too large a mass of oxidable metal would be required to produce decisive results. After reflecting, however, on the slow and weak action of sea water on copper, and the small difference which must exist between their electrical powers; and knowing that a very feeble chemical action would be destroyed by a very feeble electrical force, he was encouraged to proceed; and the results were highly satisfactory and conclusive. A piece of zinc, not larger than a pea, or the point of a small iron nail, was found fully adequate to preserve forty or fifty square inches of copper; and this, wherever it was placed, whether at the top, bottom, or in the middle of the sheet of copper, and whether the copper was straight or bent, or made into coils. And where the connexion between the different pieces of copper was completed by wires, or thin filaments of the fortieth or fiftieth of an inch in diameter, the effect was the same; every side, every surface, every particle of the copper remained bright, whilst the iron, or the zinc, was slowly corroded.

A piece of thick sheet copper, containing on both sides about sixty square inches, was cut in such a manner as to form seven divisions, connected only by the smallest filaments that could be left, and a mass of zinc, of the fifth of an inch in diameter, was soldered to the upper division. The whole was plunged under sea water; the copper remained perfectly polished. The same experiment was repeated with iron, and after the lapse of a month, the copper was in both instances found as bright as when it was first introduced, whilst similar pieces of copper, undefended, underwent in the same water very considerable corrosion, and produced a large quantity of green deposit in the bottom of the vessel.

Numerous other experiments were performed, and with results equally conclusive of the truth of the theory which had suggested them.

There was, however, one point which still remained for enquiry. As the ocean may be considered in its relation to the quantity of copper in a ship, as an infinitely extended conductor, it became necessary to ascertain whether that circumstance would influence the results. For this purpose, he placed two very fine copper wires, one undefended, the other defended by a particle of zinc, in a very large vessel of sea water, which water might be considered to bear the same relation to so minute a portion of metal, as the sea to the metallic sheathing of a ship. The result was perfectly satisfactory. The defended copper underwent no change; the undefended tarnished, and deposited a green powder.*

Davy having thus satisfied his own mind as to the truth of his views, communicated to Government, in January 1824, the important fact of his having discovered a remedy for the evil of which they had complained; and that the corrosion of the copper sheathing of his Majesty's ships might be prevented by rendering the copper electro-positive, by means of the contact of tin, zinc, lead, iron, or any other easily oxidable metal; and that he was prepared to carry his plan into effect.

A proposition from a philosopher of such known science, and upon a subject of such great importance to the navigation and commerce of the country, immediately obtained all the attention it deserved; and an order was made that the plan of protection should, under the superintendence of Sir H. Davy, be forthwith tried upon the bottom of a sailing cutter.

To give to his discovery farther publicity, Sir Humphry requested that three models of ships might be exhibited in the spacious hall of the Navy Office in Somerset House; the copper of one of which he proposed should be protected by bands of zinc, that of another by plates of wrought iron soldered on the sheathing; while the third should have its copper exposed without any protection whatever.

These models were floated in sea water for several months; and the experiment fully confirmed the results he had previously obtained in his labora-

* During the course of some experiments in which I have been lately engaged, a simple mode of exhibiting the principle of protection occurred to me, which I believe has not before been suggested; at least I cannot find any notice of such an experiment. As I consider it admirably calculated for illustration, I will here describe it. Let two slips of copper of equal size, the one protected with a piece of zinc, the other unprotected, be plunged into two wine glasses filled with a solution of ammonia. In a short time, the liquor containing the unprotected copper will assume an intensely blue colour, the other will remain colourless for any length of time. The theory is obvious. When metallic copper is placed in contact with an ammoniacal solution, a protoxide of the metal is formed which is colourless, and will remain so, if the contact of air be prevented; but on exposure to the atmosphere, it passes into a state of peroxide, which is dissolved by the ammonia, and produces an intensely blue solution. In the case of the protected copper, the metal is incapable of attracting a single atom of oxygen, in consequence of having been rendered negative by the zinc, and consequently no solution can take place.

tory. The models were, from time to time, examined by persons of the highest scientific character, as well as by others of great naval celebrity; and so alluring was the theory, and so conclusive the experiments, that, instead of waiting the result of the slow but more certain ordeal to which the plan had been submitted, it was immediately put into extensive practice, both in the Government-service and on the bottoms of ships belonging to private individuals.

To those the least acquainted with the principles of Voltaic action, it was only necessary to state the proposition, in order to command their assent to its truth. The utility of the plan therefore was never questioned, but the claims of Davy to the originality of the invention were doomed to meet with immediate opposition.*

The correctness of the principle having been established, it became, in the next place, necessary to determine the most eligible metal to be used for protection; the proportion which it must bear to the surface of the copper-sheathing below the water-line; the form least likely to offer resistance to the sea, and to impede the sailing of the vessel; and lastly, its most convenient position on the ship's bottom. To ascertain these several points, Lord Melville and the Lords of the Admiralty desired the Commissioners of the Navy Board, and of the Dock-yards, to afford Sir Humphry every assistance and facility for prosecuting the necessary experiments; and he accordingly made many very extensive trials, not only on copper sheets which were immersed in the sea, but also on the bottoms of a considerable number of boats which had been coppered for that purpose, and exposed to the flow of the tide in Portsmouth harbour; upon which occasions, he varied the nature as well as the proportions of the protecting metal. The results were communicated to the Royal Society, and they constituted the materials for his second memoir on the subject.

* Amongst other counter-claims, there appeared in a weekly publication entitled "The Mechanic's Magazine," a statement in favour of a person of the name of Wyatt, founded on the following advertisement in "The World" newspaper of April 16, 1791. "By the King's Patent, tinned copper sheets and pipes manufactured and sold by Charles Wyatt of Birmingham. These sheets, amongst other advantages, are particularly recommended for sheathing of ships, as they possess all the good properties of copper, with others obviously superior." It is unnecessary to observe that, except their object, there is nothing in common in the inventions of Davy and Wyatt. The superiority claimed by Wyatt consisted merely in coating the copper with some substance less corrosive by sea-water than that metal: an idea borrowed from the common practice of tinning copper vessels.

"When the metallic protector was from $\frac{1}{20}$ to $\frac{1}{110}$ parts of its surface, there was no corrosion nor decay of the copper; with smaller quantities, such as from $\frac{1}{200}$ to $\frac{1}{400}$, the copper underwent a loss of weight, which was greater in proportion as the protector was smaller; and, as a proof of the universality of the principle, it was found that even $\frac{1}{1000}$ part of cast iron saved a certain proportion of the copper.

"The sheeting of boats and ships, protected by the contact of zinc, or cast and malleable iron in different proportions, compared with those of similar boats and sides of ships unprotected, exhibited bright surfaces, whilst the unprotected copper underwent rapid corrosion, becoming first red, then green, and losing a part of its substance in scales. Fortunately, in the course of these experiments, it was proved that cast iron, the substance which is cheapest and most easily procured, is likewise most fitted for the protection of the copper. It lasts longer than malleable iron, or zinc; and the plumbaginous substance which is left by the action of sea water upon it, retains the original form of the iron, and does not impede the electrical action of the remaining metal."

In the earlier stage of the investigation, it had been suggested by Mr. Knowles, and several other persons, that by rendering the copper innoxious, it was probable sea weeds might adhere to the sheets; but this objection he answered by stating, that negative electricity could not be supposed favourable to animal and vegetable life; and as it occasioned the deposition of magnesia, a substance exceedingly noxious to land vegetables, upon the copper surface, he entertained no difficulty upon that subject; in this, however, he was fatally mistaken. He found, after a trial of several weeks, that the metallic surface became coated with carbonate of lime and magnesia, and that, under such circumstances, weeds adhered to the coatings, and marine insects collected upon them; but, at the same time he observed, that when the proportion of cast iron, or zinc, was below $\frac{1}{150}$, the electrical power of the copper being less negative, no such deposition occurred; and that although the surface had undergone a slight degree of solution, it remained perfectly clean; a fact which he considered of great importance, as it pointed out the *limits of protection;* and makes the application of a *very small* quantity of the oxidable metal more advantageous, in fact, than that of a larger one.

During the course of these experiments, many singular facts occurred to him, which tended to confirm his views of electro-chemical action. Amongst the various details which remained for his investigation, the relations between the surface of the protector, and that of the copper sheathing, under the different circumstances of temperature, saltness of the sea, and rapidity of the ship's motion, presented themselves as objects of great importance; and an opportunity occurred which enabled him to pursue them by actual observation and experiment.

In the month of June 1824, a steam-vessel, H. M. ship the Comet, was, at the express request of the King of Denmark, ordered to proceed to Heligoland, for the purpose of fixing with precision, by means of numerous chronometers, the longitude of that island, in order to connect the Danish with the British survey; and the Board of Longitude having recommended that the voyage should be extended as far as the Naze of Norway, for the purpose of ascertaining also the longitude of that important point, Sir H. Davy thought that this vessel would afford him the means of performing his desired experiments upon protected and unprotected copper sheets, when under the influence of rapid motion; and upon application to the Board of Admiralty, he obtained the entire disposal of the vessel after the required observations had been completed, as long as the season would allow her going to sea; and that every facility might be afforded him, a skilful carpenter was put on board, to prepare whatever might be necessary for the prosecution of the enquiry.

For the following account of his adventures upon this occasion, I am indebted to Dr. Tiarks, who, in his character of astronomical observer, superintended the expedition.

In the first instance, Davy directed to be constructed a number of oblong, rectangular, thin plates of copper, the surface of which should exceed that of a square foot; in the centre of these plates was fastened a slip of copper, by means of which other pieces of copper, which had small plates of iron of various dimensions attached to them, were fixed to the plate, by merely sliding them into the groove thus prepared for their reception. The plates were all carefully weighed previously to the experiment, and the pieces of iron were considered as representing the various proportions of iron and copper surfaces within whose limits Sir H. Davy had been led, by former experiments, to expect that the best proportion would be found. These plates were afterwards slipped into wooden frames, and nailed to the ship's side, over a piece of thick canvass, for the purpose of intercepting every possible communication between them and the copper sheathing.

It was proposed that, after each trip, these plates should be accurately weighed, in order to ascertain the loss which they severally might sustain from the corrosive action of the sea, while thus protected by different proportions of iron surface; and to ensure every possible accuracy, he carried with him the excellent balance, constructed by Ramsden, which is in possession of the Royal Society.

Sir H. Davy, accompanied by Lord Clifton, embarked at Greenwich on the 30th of June, and the vessel arrived at Heligoland on the 2nd of July. Here, as they remained not more than one day, the plates were not examined, although the Master expressed strong doubts as to their safety. The vessel then proceeded, by order of Sir Humphry, to Norway, a country which he was, for several reasons, very desirous of visiting, especially for the sake of determining a doubtful point in ornithology, upon which he subsequently corresponded with Professor Rheinhard, of Copenhagen.

The difference of longitude, also, between that country and Greenwich, not having been accurately ascertained, offered perhaps an additional reason for thus deviating from a course which, it must be confessed, was at variance with the original plan of the expedition.

After a severe gale of wind on the 4th of July, the vessel arrived, on the day following, at Rleve, near Mandal, and afterwards proceeded to this latter place, at which Davy remained for several days, during which interval the vessel made a tour to the Naze, and took in coal.

On the arrival of the vessel in the port, the plates were immediately examined; but, to the great disappointment of Sir Humphry, it was discovered, that every one of the protectors had been washed away, and that most of the plates had sustained considerable injury.

With the country around Mandal, he was much pleased; for, although it is far from being fertile, the scenery is rendered exceedingly striking and beautiful by the numerous lakes which wash the feet of high and sometimes perpendicular mountains, at that time clothed with the rich verdure of their summer herbage.

Sir Humphry made several excursions into the interior of the country, and derived much amusement from angling in the lakes; and had it not been from his own inspection of the roads, and the information which he collected respecting them, together with an indisposition of his fellow-traveller, Lord Clifton, he would have made an extensive land journey through the country; but, under the existing circumstances, he determined to return to England through Denmark and Germany. He therefore at once resolved to take the steam-boat with him as far as Sweden, where the excellent roads would enable him, without inconvenience, to reach Gottenburg, and thence to continue his route through Denmark to Germany. The vessel proceeded accordingly to Christiansand, the chief town of a country of the same name.

Having been provided with some spare plates and protectors, he fixed them to the ship's side at Mandal, as he was informed that the voyage could be entirely performed within the rocks, with which the whole coast of Norway is so plentifully studded; but a short traverse through an open part of the sea, not far from Mandal, again defeated his object. The protectors were washed away, and no result was obtained.

At Christiansand he remained a few days, in order to try some new plates, which were constructed there under his own inspection. Upon this occasion he made an excursion to the falls of the Torjedahl, distant about six miles from the town. The river abounds with salmon, which were easily caught in their descent from the falls, by an apparatus contrived for that purpose. Sir Humphry amused himself by teaching the inhabitants the operation of *crimping*, and he declared the flavour of the fish to be superior to any salmon he had ever tasted.

It was at Christiansand that he became acquainted with the Norwegian race of ponies, so well adapted for mountainous countries; and which, at his recommendation, were afterwards introduced into England by Mr. Knight, of Downton Castle.

From Christiansand the vessel proceeded on her route eastward to Arendal, where she arrived on the 12th, after a passage of only a few hours, The route lay entirely within the rocks, and so narrow were the passages, that the vessel could frequently not pass the rocks on either side without touching them.

At Arendal, which is the chief place of a remarkable mining district, Sir Humphry was well received by the Messrs. Dedehamys, two brothers, and the leading merchants of the place, with whom he made several excursions to the neighbouring mines. He was also invited by them to meet at their beautiful country seats, the most respectable inhabitants of the town.

In the house of Mr. Dedehamy, Davy was introduced into Norwegian society, and, for the first time, had an opportunity of witnessing the customs and manners of the country.

A short time before dinner, the guests were summoned to partake of pickled fish, anchovies, and smoked salmon, with rum, brandy, and wine, which were placed on small tables in the drawing-room in which the company assembled. This custom of taking salt provisions, together with spirits, just before dinner, is very general in the North, and is considered as the best means of preparing the stomach, and of provoking an appetite for the approaching meal.

The very numerous party, which, with the exception of the hostess and her daughter, consisted entirely of men, were then ushered into two large rooms, one not being sufficiently spacious to accommodate them, and each person took his seat promiscuously. At the beginning of the dinner, large basins filled with sugar were carried round by the host's daughter, followed by a servant, from which each gentleman took a large handful. Sir Humphry, surprised at so singular a ceremony, enquired its meaning, when the host very good-humouredly answered, that in Norway they thought, if the wine was good it could not be spoiled by sugar, and if bad, that it would be improved by it. Davy immediately followed the example of the company, and helped himself to the sugar.

Amongst the party present were several members of the Diet (Storthing), which had recently refused the applications of the King for various grants of money. This subject excited much animated conversation, and the majority of the persons present expressed their approbation at so bold and independent a measure. This called forth a political toast relating to the situation of their country, when the whole company, elated with wine and conversation, simultaneously burst forth into the national chorus of Norway, which had been composed as a prize poem during the short struggle against the union of that country with Sweden, and which was much admired by the Norwegians, and on all occasions sung by them with the utmost enthusiasm of feeling; but, notwithstanding the liberal politics of the party, they drank Sir Humphry's toast—"The King of Norway and Sweden,"—with much apparent loyalty.

A succession of toasts followed, the last of which recommended "The British Constitution as a model for all the world." With this sentiment the festivities concluded—a momentary silence ensued; the custom of the country assigned to a stranger the honourable office of returning to the host and hostess the thanks of the company for their hospitable reception; all eyes were anxiously fixed upon the English philosopher; and as soon as he was made acquainted with the duty he was expected to perform, he rose from his seat, and in allusion to the sentiment so recently drunk in compliment to himself, he proposed as a concluding toast, " NORWEGIAN HOSPITALITY A MODEL FOR ALL THE WORLD."

From Arendal the vessel proceeded to Laurvig, where she stopped only a few hours; but Sir Humphry seized this opportunity to go on shore to view the country, and he afterwards weighed the copper plates which had been attached to the ship in Christiansand, as the vessel was now to cross that deep bay, at the bottom of which is situated Christiana, the capital of the kingdom. The few plates were found to be in good order; and the results, which however must be allowed to have been very incomplete, confirmed, as far as they went, the conclusions to which he had been led by former experiments, viz. that $\frac{1}{200}$ of iron surface was the proportion best calculated to defend the copper, without so over protecting it as to favour the adhesion of marine productions; while they moreover proved that there is a mechanical as well as a chemical wear of the copper, which, in the most exposed part of the ship, and in the most rapid course, bears a relation to it of nearly 2 to 4.55.

The country increased in fertility towards the eastern parts of it; but it possessed much less beauty than the neighbourhood of Mandal.

As soon as Davy perceived that the vessel had to pass near the mouth of the Glommen, the largest river of Norway, he directed that she should enter it. Steam-boats appeared to have been entirely unknown in that part of the country. The inhabitants of the town of Frederickstadt were alarmed by the belief that the vessel was on fire, and they ran down to the beach in multitudes. As the vessel proceeded up the river, the people every where left their work, looked on awhile in silent amazement, and then shouted with delight.

The vessel anchored a mile below the great fall of the Glommen, called *Sarpen*, and which Davy visited on the following day (July 15). Three Kings of Denmark have visited this fall, and a name commemorates the spot whence they viewed this grand scene of nature. The fall is not one perpendicular descent, but consists of three sheets of water closely succeeding each other, and, by means of a barometer, he ascertained the entire altitude to be little more than a hnndred feet. In comparing the character of this waterfall with those of the others he had visited, he observes, that size is merely comparative; and that he prefers the Velino at Terni, on account of the harmony that exists in all its parts. It displays all the force and power of the element, in its rapid aud precipitous descent; and you feel that even man would be nothing in its waves, and would be dashed to pieces by its force. The whole scene is embraced at once by the eye, and the effect is almost as sublime as that of the Glommen, where the river is at least one hundred times as large; for the Glommen falls, as it were, from a whole valley upon a mountain of granite; and unless where you see the giant pines of Norway, fifty or sixty feet in height, carried down by it and swimming in its whirlpools like straws, you have no idea of its magnitude and power. Considering these waterfalls in all their relations, he is disposed to think, that while that of Velino is the most perfect and beautiful, the fall of the Glommen is the most awful.

On both sides of this fall are extensive saw-mills, with machinery of very imperfect construction. Davy spent some time with the proprietors of these mills, who were acquainted with the English language, and showed him every attention in their power. As an angler, he spoke with regret of the immense quantity of sawdust which floated in the water, and formed almost hills along the banks, and which, he observed, must be poisonous to the fish, by sometimes choking their gills, and interfering with their respiration.

From the Glommen the steam-vessel passed through the Svinesund to Strömstadt, the first town in Sweden beyond the frontier of Norway, from which Charles XII. essayed to besiege the neighbouring fortress of Frederickstadt in Norway. From Strömstadt, Davy set out on the 17th of July, and reached Gottenburg by land in two days, where he remained for a short time, in consequence of a slight indisposition. On his journey, he had a conversation with Oscar, the Crown Prince of Denmark, who, under the direction of Berzelius, had diligently devoted himself to the study of chemistry. He conversed with our philosopher upon various subjects connected with that science; and Davy, on his return to England, declared that he had never met with a more enlightened person.

The Crown Prince expressed great surprise, as indeed did every body in Sweden, on hearing that it was not Davy's intention to visit Professor Berzelius at Stockholm; and his astonishment was still farther increased, when he was informed by himself, that he came to Norway and Sweden with no other view than to enjoy the diversion of hunting and fishing!

Davy, however, did by accident afterwards meet Berzelius, but his interview was but of short duration.

From Gottenburg he hastened to Copenhagen, where he renewed his acquaintance with Prince Christian of Denmark, cousin of the King, and heir presumptive of the crown; in whose company he had some years before observed an eruption of Mount Vesuvius. He also visited Professor Oersted, and earnestly requested that he might see the apparatus by which that philosopher had made those electro-magnetic experiments, which had rendered his name so celebrated throughout Europe.

He next proceeded to Neuburg and Altona, where he intended to re-imbark for England in the steam-vessel which had, during the interval of his continental tour, made a voyage to England, and was again on her way to the Elbe. At the suggestion, however, of Professor Schumacher, the astronomical professor at Copenhagen, but residing at Altona, in whose society he passed a great portion of his time, he accompanied that gentleman to Bremen, in order to make the acquaintance of the venerable Dr. Olbers, who since his retirement from an extensive medical practice, had entirely devoted his time to the pursuit of his favourite science astronomy; as well as to be introduced to Professor Gauss, of Gottingen, who happened to be at that time carrying on his geodetical operations for the admeasurement of the kingdom of Hanover.

Davy expressed a great desire to see the telescope with which Dr. Olbers had discovered the two planets, Pallas and Vesta, and which to his great surprise turned out to be a very ordinary instrument. His personal intercourse with these two celebrated philosophers appeared to afford him the highest satisfaction; and he spent two days most agreeably in their society.

In his Salmonia, he gives us some account of his adventures as an angler during this short excursion to Norway and Sweden. "All the Norwegian rivers," says he, "that I tried (and they were in the southern parts) contained salmon. I fished in the Glommen, one of the largest rivers in Europe; in the Mandals, which appeared to me the best fitted for taking salmon, and in the Arendal; but, though I saw salmon rise in these rivers, I never took a fish larger than a sea trout; of these I always caught many—and even in the *fiords*, or small inland salt-water bays; but I think never any one more than a pound in weight. It is true that I was in Norway in the beginning of July, in exceedingly bright weather, and when there was no night; for even at twelve o'clock the sky was so bright, that I read the smallest print in the columns of a newspaper. I was in Sweden later—in August: I fished in the magnificent Gotha, below that grand fall, Trollhetta, which to see is worth a voyage from England; but I never raised there any fish worth taking. I caught, in this noble stream, a little trout about as long as my hand; and the only fish I got to eat at Trollhetta was bream."

Davy again embarked on the 14th of August, on board the Comet steam-vessel, which had ascended the Weser as high as her draught of water would allow, and reached England, after a very boisterous passage, on the 17th of the same month; indeed, the vessel left the mouth of the Weser with a contrary wind, and the pilot was unwilling to put to sea, but Davy insisted on proceeding without delay. During the whole passage he suffered extremely from sea-sickness, and in a letter written to Professor Schumacher, shortly after landing, he remarks that "the sea is a glorious dominion, but a wretched habitation."

On the 9th of June 1825, Sir Humphry read before the Royal Society his third and most elaborate paper upon Copper sheathing, entitled "Farther Researches on the Preservation of Metals by Electro-chemical Means."

In this memoir, he states it to be his belief, that there is nothing in the poisonous nature of the copper to prevent the adhesion of weeds and testaceous animals; for he observes, that they will readily adhere to the poisonous salts of lead which commonly form upon the metal protecting the fore-part of the keel; and even upon copper, provided it be in such a state of chemical combination as to be insoluble. It is then, in his opinion, the *solution* of the metal—the *wear* of its surface, by keeping it smooth, which prevents the adhesion of foreign matter. Whenever the copper is unequally worn, deposits will, without doubt, rest in the rough parts, or depressions in the metal, and afford a soil or bed in which sea-weeds can fix their roots, and to which zoophytes and shell-fish can adhere; but there is another cause of foulness on the protected sheathing, arising from the deposit of earthy matter upon the copper, in consequence of its electro-negative condition.

In relation to this subject, Davy has offered some observations upon the effects produced by partial formations of rust, which appear to me to be exceedingly interesting and important.

When copper has been applied to the bottom of a ship for a certain time, he says, a green coating, or rust, consisting of oxide, sub-muriate, and carbonate of copper, forms upon it; not equally throughout, but partially, and which, it is evident, must produce a *secondary*, partial, and unequal action, since those substances are negative with respect to metallic copper, and will consequently, by producing with it a Voltaic circuit, occasion a more rapid corrosion of those parts still exposed to sea water; from this cause, sheets are often found perforated with holes in one part, after having been used for five or six years, while in other parts they are comparatively sound.* In like manner the heads of the mixed metal nails, consisting of copper alloyed by a small quantity of tin, which are in common use in the navy, give rise to oxides that are negative with respect to the copper, so that the latter is often worn into deep and irregular cavities in their vicinity.

A series of very interesting experiments, fully detailed in this memoir, which were instituted for the purpose of ascertaining the extent of the diminution of electrical action in instances of imperfect or irregular conducting surfaces, led him to the general conclusion, that a very small quantity of the imperfect or fluid conductor was sufficient to transmit the electrical power, or to complete the chain. This induced him to try whether copper, if nailed upon wood, and protected merely by zinc or iron on its *under* surface, or on that next the wood, might not be defended from corrosion; a question of great practical moment with regard to the arrangement of protectors. For this purpose, he covered a piece of wood with small sheets of copper, a nail of zinc of about $\frac{1}{100}$ part of the surface having been previously driven into the wood; the copper surface remained perfectly bright in sea water for many weeks, and when the result was examined, it was found that the zinc had only suffered partial corrosion; that the wood was moist, and that, on the interior of the copper, there was a considerable portion of revived zinc, so that the negative electricity, by its operation, provided materials for its future and constant excitement. In several trials of the same kind, iron was used with similar results; and in all these experiments there appeared to be this peculiarity in the appearance of the copper, that unless the protecting metal below was in a large mass, there were no depositions of calcareous or magnesian earths upon the metal; it was clean and bright, but never coated. The copper in these experiments was nailed sometimes upon paper, sometimes upon the mere wood, and sometimes upon linen; and the communication was partially interrupted between the external and internal surfaces by cement; but even one side or junction of a sheet seemed to allow sufficient communication between the moisture on the under surface and the sea water without, to produce the electrical effect of preservation. This last experiment of Davy is of greater importance than may at first appear, in showing what a small propor-

* The rusting of a common piece of iron, if carefully inspected, furnishes a beautiful illustration of this secondary action. The oxide, at first a mere speck, and formed perhaps by a globule of water, becomes negative with respect to the contiguous surface, and by thus forming a Voltaic circuit, exalts its oxidability, and the rust consequently extends in a circle.

tion of conducting fluid will complete a circuit, and in thus explaining phenomena, as I shall presently show, which might not otherwise be suspected to have an electrical origin.

These results upon perfect and imperfect conductors, led him to another enquiry, important as it relates to the practical application of the principle, namely, as to the extent and nature of the contact or relation between the copper and the preserving metal. He was unable to produce any protecting action of zinc or iron upon copper through the thinnest stratum of air, or the finest leaf of mica, or of dry paper; but the action of the metals did not seem to be much impaired by the ordinary coating of oxide or rust; nor was it destroyed when the finest bibulous, or *silver paper*, as it is commonly called, was between them, being moistened with sea water. He made an experiment with different folds of this paper. Pieces of copper were covered with one, two, three, four, five, and six folds; and over them were placed pieces of zinc, which were fastened closely to them by thread; each piece of copper, thus protected, was exposed in a vessel of sea water, so that the folds of paper were all moist.

It was found in the case in which a single leaf of paper was between the zinc and the copper, there was no corrosion of the copper; in the case in which there were two leaves, there was a very slight effect; with three, the corrosion was distinct; and it increased, till with six folds the protecting power appeared to be lost; and in the case of the single leaf, the result differed only from that produced by immediate contact, in there not being any deposition of earthy matter. Other experiments likewise proved that there was no absolute contact of the metals through the moist paper; for, although a thin plate of mica, as before stated, entirely destroyed the protecting effect of zinc, yet when a hole was made in it, so as to admit a very thin layer of moisture between the zinc and copper, the corrosion of the latter, though not prevented, was considerably diminished.

The experimental part of this paper concludes with an account of various trials to determine the electro-chemical powers of metals in menstrua out of the contact, or to a certain extent removed from the contact of air; in order, if possible, to diminish the rapid waste of the protecting metals. In the progress of these experiments he exhibits, in a most beautiful manner, the singular effect of different proportions of a fixed alkali, when mixed with sea water, in rendering the iron, in its Voltaic connection with copper, more or less negative.

He terminates the paper with some observations of a practical nature, relative to the best modes of rendering iron applicable to the purposes of protection; but, as these have been already embodied in the investigation, it is not necessary to notice them farther in this place.

That I may give to the history of this subject all the perspicuity which it can derive from the connexion of its several parts, I shall now, in defiance of chronological order, proceed to consider his last Bakerian Lecture, " On the Relations of Electrical Changes," which was read before the Royal Society, on the 8th of June 1826. In which, after referring to his former papers on the chemical agencies of electricity, and the general laws of decomposition which were developed in them, he enters into some historical details respecting the origin and progress of electro-chemical science; being induced so to do, from a knowledge of the very erroneous statements which had been published upon the subject abroad, and repeated in this country. At the conclusion of this lecture, in reverting to the subject of Voltaic protection, he says, " A great variety of experiments made in different parts of the world have proved the full efficacy of the electro-chemical means of preserving metals, particularly the copper sheathing of ships; but a hope I had once indulged, that the peculiar electrical state would prevent the adhesion of weeds or insects, has not been realized; protected ships have often indeed returned, after long voyages, perfectly bright,* and cleaner than unprotected ships; yet this is not always the case; and though the *whole* of the copper may be preserved from chemical solution in steam-vessels (from the rapidity of their motion) by these means,—yet they must be adopted in common ships only so as to preserve a portion,—so applied, as to suffer a certain solution of the copper;† and an absolute remedy for adhesions, is to be sought for by other more refined means of protection, and which appear to be indicated by these researches.

" The nails used in ships are an alloy of copper and tin, which I find to be

* The Carnbrea Castle, a large vessel, of upwards of six hundred and fifty tons, was furnished with four protectors, two on the stern, and two on the bow, equal together to about 1-104th of the surface of copper. She had been protected more than twelve months, and had made the voyage to Calcutta and back. She came into the river perfectly bright; and, when examined in the dry-dock, was found entirely free from any adhesion, and offered a beautiful and almost polished surface; and there seemed to be no greater wear of copper than could be accounted for from mechanical causes.

† A common cause of adhesions of weeds or shell-fish, is the oxide of iron formed and deposited round the protectors. In the only experiment in which zinc has been employed for this purpose in actual service, the ship returned after two voyages to the West Indies, and one to Quebec, perfectly clean. The experiment was made by Mr. Lawrence, of Lombard Street, who states that the rudder, which was not protected, had corroded in the usual manner.

slightly negative with respect to copper, and it is on these nails that the first adhesions uniformly take place: a slightly positive and slightly decomposable alloy would probably prevent this effect, and I have made some experiments favourable to the idea."

He next proceeds to state some circumstances, in addition to those he had formerly noticed, by which the electrical relations of copper are altered. "I found," says he, "copper hardened by hammering, *negative* to rolled copper;—copper (to use the technical language of manufacturers) both *over-poled*, and *under-poled*,* containing, in one case, probably a little charcoal, and in the other a little oxide, *negative* to pure copper. A specimen of brittle copper, put into my hands by Mr. Vivian, but in which no impurity could be detected, was negative with respect to soft copper. In general, very minute quantities of the oxidable metals render the alloy positive, unless it becomes harder, in which case it is generally negative."

These are important facts, and should dispose those who may preside over judicial enquiries, to pause before they infer the inferiority of copper sheeting

* The *poling* of copper is an operation, the theory of which is involved in a great deal of mystery. Copper, when taken from the smelting furnace, is what is termed *dry*, that is, it is brittle, has an open grain and crystalline structure, and is of a purplish red colour. The following is the process by which it is refined, or *toughened*, by the process of *poling*. The surface of the melted metal in the furnace is, in the first place, covered with charcoal. A pole, commonly of birch, is then plunged into the liquid metal, which produces a considerable ebullition from the evolution of gaseous matter, and this operation is continued, fresh charcoal being occasionally added, so that the surface may be always kept covered, until the refiner judges from the assays that the metal is malleable. The delicacy of the operation consists in the difficulty of hitting the exact mark: if the surface should by accident be uncovered, it will return to its *dry* state, and should the process be carried too far, it will be *over-poled*, by which the metal would be rendered even more brittle than when in a *dry* state. When this is found to be the case, or, as they say, *gone too far*, the refiner directs the charcoal to be drawn off from the surface of the metal, and the copper to be exposed to the action of the air, by which means it is again brought back to its *proper pitch*, that is, become again malleable. Now the question is, what are the changes thus produced in the copper? Is the metal in its *dry* state combined with a minute portion of oxygen, of which *poling* deprives it, and thus renders it malleable? and does the *over-poling* impart to it a minute portion of carbon, and is copper, like iron, thus rendered brittle both by oxygen and carbon? Or, is the effect of the pole merely mechanical, that of closing the grain, and of altering the texture of the metal? Something might be said in support of all these opinions. Mr. Faraday, who has attentively examined the subject, is unable to detect any chemical difference between *poled* and *unpoled* copper. On the other hand, when the metal is *over-poled*, it is found to oxidate more slowly, and its surface when in the furnace is so free from oxidation, that it is like a mirror, and reflects every brick in the roof. This certainly looks very much like carbonization.—See "An Account of Smelting Copper, as conducted at the Hafod Copper-works;" by J. H. Vivian, Esq.—*Annals of Philosophy*, vol. v. p. 113.

from the rapidity of its decay.* I have now concluded a review of those admirable researches which led Sir Humphry Davy to suggest and mature a plan for arresting the corrosion of the copper sheathing of vessels by Voltaic action. Mr. Babbage has said that he was authorised in stating, that "this was regarded by Laplace as the greatest of Davy's discoveries." I do not think, however, that it should be considered in the light of a separate performance; we do injustice to the philosopher by regarding it as an independent and isolated discovery; for it was the result of a long series of enquiries, which commenced by establishing the laws of electro-chemistry,—which led him to the decomposition of the alkalies and earths,—suggested to his unwearied ge-

* This observation was suggested by an examination of a late judgment of the Court of Common Pleas, in the case of Jones *v.* Bright and others, on showing cause against rule for a new trial. This was an action brought by the Plaintiff against the Defendants for selling him copper, for the purpose of sheathing the ship Isabella, which, from the rapidity of its corrosion, was inferred to have an inherent defect in its composition. In this case it was held, that with respect to *warranty*, there is a very wide difference as it applies to articles which are not the subject of manufacture, and those which are the produce of manufacture and of human industry. In the one case, it may be that no prudence, no care, could have guarded against a secret defect; in the other, by using due care, and providing proper materials, any defect in the manufacture may be guarded against. "In the case of the bowsprit, the man did not make the timber which composed the bowsprit, he merely cut it out, and fitted it to meet the purpose, and could therefore by no means have guarded against the rottenness in the centre of that bowsprit; but if a man makes copper, he may guard against inherent defects in that copper, by taking care that the copper contains a proper proportion of pure copper; and also by taking care that it is so well manufactured that it does not drink in a greater quantity of oxygen than ought to be admitted into it, and that that oxygen, which of necessity gets in, (for some will) shall be so distributed, that it shall not operate, as in the opinion of an intelligent witness the oxygen in this case did operate, by forming itself in patches, and thereby rendering it soft, and rendering the copper incapable of resisting the influence of salt water—that he can guard against." With all due deference to the learned Judge, suppose it be shown that no human wisdom can guard against those circumstances by which a portion of the copper surface may be rendered more highly electro-positive, what becomes of the judgment? That the decay of copper sheathing is effected by extrinsic causes, and does not necessarily depend upon an inherent defect in the metal, may be proved in numerous ways. If it were owing to the quality of the copper, why should five, ten, or twenty sheets out of a hundred, made from the same charge of metal in a furnace and manufactured under precisely similar circumstances, be affected, and the remainder be perfectly sound? Why, again, should sheets, made from several distinct charges, placed on a particular vessel, be acted upon, while the same copper on other bottoms is not more than usually dissolved? Did any inherent defect exist in the metal, it surely must have equally affected the whole batch.

It is possible that, in some cases, in consequence of the sheets not having been properly cleansed before they are rolled, a portion of the oxide may be pressed into them by the rollers. In such a case, a Voltaic effect might be produced, and portions of the metallic surface rendered more electro-positive.

nius a succession of novel researches, in a new field of enquiry,—and concluded, as we have seen, in producing the most striking results by means of the greatest simplicity. Not once during the progress of this enquiry had he any occasion to retrace his steps for the purpose of correction; justly has he observed in his last Bakerian Lecture that, notwithstanding the various novel views which have been brought forward in this and other countries, and the great activity and extension of science, it is peculiarly satisfactory to find that he has nothing to alter in the fundamental theory laid down in his original communication; and which, after the lapse of twenty years, has continued, as it was in the beginning, the guide and foundation of all his researches.

The President and Council of the Royal Society appear to have been swayed by this consideration, when they adjudged to him "A Royal Medal,* for his Bakerian Lecture on the relations of electrical changes, considered as the last link, in order of time, of the splendid chain of discoveries in chemical electricity, which have been continued for so many years of his valuable life."

Thus had Davy now received from the Royal Society all the honours they were capable of conferring upon him. In the year 1805, they adjudged to him the medal on Sir Godfrey Copley's donation for his various communications published in the Philosophical Transactions. In 1817, they awarded him the Rumford medals for his papers on combustion and flame; and in 1827, upon the grounds just stated, the President and Council expressed their unabated admiration by conferring upon him the only medal which remained for his acceptance—that which had been recently founded by their patron, his late Majesty.

Having thus disposed of the speculative part of his admirable enquiry, it will be interesting to pause in our narrative, in order to take a philosophical review of the progress of Voltaic discovery, in its relations to this particular object. It is a subject well calculated to afford a valuable lesson to the experimentalist, and at the same time to furnish illustrations, more striking even than that of the safety-lamp, of the necessity of that complicated species of machinery, without which the human mind is frequently unable to grapple with the simplicities of truth; it is true, that the fact of a galvanic effect being

* In the year 1825, His Majesty George IV. communicated to the Royal Society, through Mr. Peel, his intention to found two gold medals, of the value of fifty guineas each, to be awarded annually by the Council of the Royal Society, in such a manner as shall, by the excitement of competition among men of science, seem best calculated to promote the object for which the Royal Society was instituted.

excited by the contact of two dissimilar metals was noticed in the earliest stages of the enquiry, but it is equally evident that the phenomena which attended it, and the laws by which it was directed, required for their discovery and elucidation the assistance of the Voltaic battery. In reference to Davy it may be here repeated, that the power of obtaining simple results, through complicated means, was one of the most distinguishing features of his genius.

It has been stated, that the Alarm frigate, the first coppered ship in our navy, displayed very striking evidence of the effect of Voltaic action, in the rapid corrosion of its iron.* As early as 1783, after copper sheathing had become general, the Government issued orders that all the bolts under the line of fluitation should, in future, be of copper; but at that period, it was not possible that any idea could be entertained as to the true nature of the operation by which the iron was thus rapidly corroded, for it was only in the year 1797 that Dr. Ash noticed, for the first time, a phenomenon which was subsequently referred to the action of a simple Voltaic circuit.

It is a very curious circumstance in the history of this subject that, for many years after the Voltaic influence had been recognised as the agent in metallic corrosion, so far from the existence of the accompanying phenomenon of preservation being suspected, it was even supposed that the metals mutually corroded each other. At so late a date as 1809, we find Davy himself, in the letter addressed to M. Alavair, published in these memoirs,† dwelling upon the necessity of avoiding metallic contact, in order to prevent *corrosion*, without throwing out the most distant hint as to the simultaneous production of a converse effect.

The first distinct notice of a metal being preserved from oxidation by the contact of a dissimilar metal, is at once referred to a chemical law, without a reference even to its possible connection with Voltaic action; and, striking as the fact may now appear, it never attracted much attention. M. Proust observed, that although copper vessels be so imperfectly tinned, as to leave portions of the surface uncovered, still, in cooking utensils, we shall be equally protected from the poisonous effects of the former metal; because, says he, the

* Numerous are the instances of later date which might be adduced in illustration of the same fact; and it is now generally supposed that it may have been a frequent cause of ships foundering at sea. By oxidation, the volume of the iron at first encreases, and then diminishes; in consequence of which the ship leaks, or, to use a technical expression, becomes "*bolt sick*." When the Salvador del Mundo was docked at Plymouth, in February 1815, the iron fastenings were in such a state of corrosion, that five planks near the bilge dropped into the dock when the water left her.

† Page 269.

superior readiness with which tin is oxidized and acted upon by acids, when compared with copper, will not allow this latter metal to appropriate to itself a single atom of oxygen.* The same chemist observes, that if lead be associated with tin, it will be incapable of furnishing to acids any saturnine impregnation, since the latter, being more oxidable than the former, will exclusively dissolve, and thus prevent the former from being attacked.

Whether the principle of Voltaic protection be applicable or not to the purpose of preserving copper sheathing, it is evident that it will suggest numerous other expedients of high importance in the arts, while it will explain phenomena previously unintelligible. By introducing a piece of zinc, or tin, into the iron boiler of the steam-engine, we may prevent the danger of explosion, which generally arises, especially where salt water is used, as in those of steam-boats, from the wear of one part of the boiler. Another important application is in the prevention of the wear of the paddles, or wheels, which are rapidly dissolved by salt water.

Mr. Pepys has also extended the principle for the preservation of steel instruments by guards of zinc; razors and lancets may be thus defended with perfect success. In the construction of monuments which are to transmit to posterity the record of important events, the artist will be careful in avoiding the contact of different metals; it is thus that the Etruscan inscriptions engraved upon pure lead are preserved to the present day, while medals of mixed metals of a much more recent date are corroded.

Numerous are the facts daily presented before us, which receive from this principle a satisfactory explanation. To the philosopher, the examination of its agencies will furnish a perpetual source of instruction and amusement; and I will here enumerate a few simple instances of its effects; in the first place, for the purpose of showing that, whenever a principle or discovery involves or unfolds a law of Nature, its applications are almost inexhaustible, and that, however abstracted it may appear, it is sooner or later employed for the common purposes of life; and in the next place, in the hope of convincing the reader, that there does not exist any source of pleasure so extensive and so permanent as that derived from the stores of philosophy. The saunterer stumbles over the stone that may cross his path, and vents only his vexation

* As far as the principle of Voltaic protection goes, this may be very true; but it must be remembered that the acid generally present upon these occasions is acetic acid, which rises in distillation with water, so that at the boiling temperature it will be carried beyond the sphere of Voltaic influence, and may thus act upon the denuded copper as much as though tin were not present.

at the interruption; but to the philosopher there is not a body, animate or inanimate, with which he can come in contact, that does not yield its treasures at his approach, and contribute to extend the pleasures of his existence.

I well remember some years ago, that, in passing through Deptford, my curiosity was excited by the extraordinary brilliancy of a portion of the gilded sign of an inn in that town, while its other parts had entirely lost their metallic lustre; having obtained a ladder, I ascended to the sign, in order, if possible, to solve the problem that had so greatly interested me—the mystery immediately vanished, for an iron nail appeared in the centre of the spot, which had protected the copper leaf for several inches around it. Any person may easily satisfy himself of the efficacy of such protection, in his rambles through the metropolis, by noticing the gilded, or rather coppered, sugar-loaves* so commonly suspended over the shops of grocers, when he will frequently perceive that the parts into which the iron supports have entered, unless the latter have been painted, shine preeminently brilliant. If a still more familiar example of the effect of a simple Voltaic circuit be required, it is afforded by the iron palisadoes, where the iron is constantly corroded at its point of contact with the lead by which it is cemented into the stone. These examples are not only interesting from their simplicity, but from their demonstrating the small quantity of a conducting fluid which is sufficient to transmit the electrical power, or to complete a simple circuit; a fact which, it will be remembered, the experiments of Davy had before established.†

As our knowledge advances, these principles will no doubt derive other illustrations, and be found capable of more extensive application; for as yet we are but in the infancy of the enquiry. I have lately been engaged in a series of experiments, the results of which, I confidently anticipate, will lead to some new facts connected with the changes produced on the negative metal of a Voltaic circuit; an account of which I hope shortly to submit to the Royal Society. I shall on this occasion merely notice one result, which appears to me to admit of an immediate application to one of the most important circumstances of life—the purity of water contained in leaden cisterns.

My attention has for several years been directed to the state of the water with which the metropolis is supplied; and upon having been lately requested to propose a remedy for preventing the action of a spring in the neighbourhood of London upon lead, which it had been found to corrode in

* There is an excellent example at this time in the London Road, leading to the Elephant-and-Castle.

† Page 411.

a very rapid manner, I suggested the expediency of protecting the pipes and cisterns with surfaces of iron; but before such a plan was put in execution, I proposed to try its efficacy in the laboratory:—the first result was very startling, for, instead of preventing, as I had anticipated, I found that it greatly increased, the solution of the lead. After various experiments, I arrived at the conclusion, that lead, when rendered negative by iron, and placed in contact with weak saline solutions, such, for instance, as common spring water, was dissolved; in consequence of the decomposition of the salts and the transference of their elements according to the general law, the acid passing to the iron, and the alkali to the lead; and so powerfully is this latter body acted upon by an alkali that, if a slip of it be immersed in a solution of potash or soda, its crystalline texture is so rapidly developed, that its surface exhibits an appearance similar to that presented by tin-plate, and which is designated by the term *moirée.*

I apprehend that most of the anomalous cases of the solution of lead in common water, which have for so many years embarrassed the chemist, may thus receive an explanation. An eminent physician lately informed me, that some time since he was called upon to attend a family who had evidently suffered from the effects of saturnine poison, and that he well remembers there was an iron pump in the cistern that supplied the water. Upon showing the results of my experiment to a no less eminent chemist, he was immediately reminded of a circumstance which occurred at Islington, where the water was found to corrode the lead in which it was received; in this vessel there was an iron bar, and the fact would not have attracted his notice, nor have been impressed upon his recollection, but from the unusual state of corrosion in which it appeared.

I shall conclude these observations by an account of " the change which some musket balls, taken out of Shrapnell's shells, had undergone," by Mr. Faraday, and which is published in the 16th volume of the Quarterly Journal of Science, for the year 1823. This history is not only interesting on account of the high chemical character of its author, but satisfactory as being in direct opposition to previously established facts; and cannot therefore have received any bias from preconceived theory.

" Mr. Marsh of Woolwich gave me some musket balls, which had been taken out of Shrapnell's shells. The shells had lain in the bottoms of ships, and probably had sea water amongst them. When the bullets are put in, the aperture is merely closed by a common cork. These bullets were variously acted upon: some were affected only superficially, others more deeply, and some were entirely changed. The substance produced is hard and brittle, it splits on the ball, and presents an appearance like some hard varieties of hæmatite; its colour is brown, becoming, when heated, red; it fuses on platinum foil into a yellow flaky substance like litharge. Powdered and boiled in water, no muriatic acid or lead was found in solution. It dissolved in nitric acid without leaving any residuum, and the solution gave very faint indications only of muriatic acid. It is a *protoxide of lead,* perhaps formed, in some way, by the galvanic action of the iron shell and the leaden ball, assisted probably by the sea water. It would be very interesting to know the state of the shells in which a change like this has taken place to any extent. *It might have been expected, that as long as any iron remained, the lead would have been preserved in the metallic state.*"

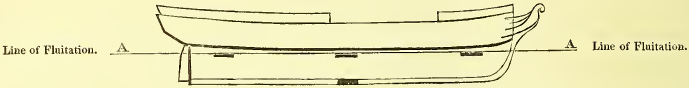
In one experiment, I found that a piece of lead protected by iron underwent solution in water containing nitrate of potash, while it resisted the action of very dilute nitric acid; upon this point, however, farther enquiry is necessary; for I subsequently failed in producing the same effect, owing no doubt to having employed too strong an acid.

Let us return from this digression to the subject of Sir Humphry Davy's Protectors. It only remains for me to relate the results which followed the practical application of the Voltaic principles which his various experiments had developed.

In the month of May 1824, directions were issued by the Lords of the Admiralty to protect, in future, the copper sheathing of all his Majesty's ships which might be taken into dock, upon the plan proposed by Sir Humphry Davy.

The protectors were bars of iron six inches wide at their base, three inches in thickness in their centre, and, in outward form, the segment of an extended circle. They were usually placed on each side of the ship in a horizontal position, viz. in midships about three feet under water—on the keel in a line with these—and the remainder in the fore and afterparts of the ship (about three feet under the line of fluitation), as far forward and abaft as the curvatures of their respective bodies would allow of their lying flat upon the surface of the copper.

As it is difficult by verbal description alone to convey a sufficiently distinct idea of this subject to persons unacquainted with naval architecture, I have introduced a sketch, exhibiting the *general* position of the *Protectors,* although they are necessarily exaggerated in size, or they would have appeared as mere specks upon the drawing.



On several ships some of the protectors, in the stem and the stern, were placed *vertically;* in which case they were fastened to the stems and stern-posts; and in this manner they were found to act more powerfully in preserving the copper than when they were all placed horizontally. The ends of the protectors were rounded, in order to prevent any great resistance to the water, and they were fastened to the bottoms of the ships with copper bolts, the iron being countersunk to receive their heads, and the holes were then filled with carbonate of lime, or Parker's cement. To bring about the best possible contact of all the copper sheets, their edges which lap over each other, where the nails are driven to fasten them to the ships, were rubbed bright, first with sand-paper, and finally with glass-paper.

Shortly after the ships thus protected were sent to sea, it was evident to all on board, from their dull sailing, that the bottoms had become very foul; and on being examined in dry docks, it was found that the copper was completely covered with sea-weed, shell-fish of various kinds, and myriads of small marine insects. Upon their removal, however, it was found, on weighing the sheets, that the copper had suffered little or no loss; thus proving that, although its practical application had failed from unforeseen circumstances, the principle of protection was true, and had fully justified the expectation of its success.

The copper near the protectors was much more foul than that at a greater distance from them; and there was, moreover, a considerable deposit of carbonate of lime, and of carbonate and hydrate of magnesia, in their vicinity.

Sir Humphry Davy immediately suggested, as a remedy for this evil, that the bottoms should be scraped, and the copper washed with a small quantity of acidulous water; and he also proposed that the protectors should in future be placed under, instead of over, the copper sheathing. This plan was immediately adopted. Discs of cast iron three and a half inches in diameter, and one-fourth of an inch in thickness, were let into the plank of the bottom of the Glasgow, of fifty guns, on the starboard side only—the larboard side having been left without any protection. These discs were in the proportion of one to every four sheets of copper, and over them were placed pieces of brown paper, and over the paper thin sheet-lead, so that the latter metal was in contact with the copper sheathing. A similar experiment was also tried on the Zebra, of eighteen guns, substituting, however, discs of zinc* for those of iron.

The bottom of the Glasgow was examined twelve months afterwards, when the discs of iron were found oxidated throughout, presenting in their appearance the characters of plumbago. The copper on the starboard side was preserved, but covered with weeds and shell-fish. The sheets on the larboard had undergone the usual waste, but were clean.

The Zebra was docked four years after the experiment had commenced, when the zinc protectors were perfect, and it did not appear that they had exerted any influence in preserving the copper, as it had wasted equally on both sides. It may be presumed in this case that the Voltaic circuit had by some fault in the arrangement been interrupted.

The apparent conversion of iron into a substance resembling plumbago, by the action of sea water, has been frequently noticed. The protectors thus changed† were, to a considerable depth from the surface, so soft as to be easily cut by a knife; but after being exposed for some time to the action of the atmosphere, they became harder, and even brittle. A portion of this soft substance having been wrapped in paper for the purpose of examination, and

* It would appear that Davy latterly preferred zinc to iron, as the protecting metal. In a letter, dated October 1826, addressed to a shipowner, who had made some enquiries of him upon the subject, he says—"The rust of iron, if a ship is becalmed, seems to promote the adhesion of weeds; I should therefore always prefer pieces of zinc, which may be very much smaller, and which, in the cases I have heard of their being used, have had the best effect."

† In the Annals of Philosophy (vol. v.) may be found a paper by Dr. Henry, on the conversion of cast iron pipes into plumbago. This change appears to have been effected by the action of water containing muriate of soda, and the muriates of lime and of magnesia. Cast iron contains a considerable portion of carbon; the change is therefore readily explained on the supposition of the removal of the principal metallic part by these salts. The muriates of lime and magnesia have been observed by Dr. Henry to discharge writing ink from the labels of bottles, to which they had been accidentally applied; and the same ingenious chemist has been baffled in his attempts to restore the legibility of ink upon paper which had been exposed to sea water. The texture of the paper was not injured, but the iron basis of the ink, as well as the gallic acid, was entirely removed.

placed in the pocket of a shipwright, gave rise to a very curious and unexpected result: at first, the artist, like Futitorious with his chestnuts, thought he perceived a genial warmth; but the effect was shortly less equivocal; the substance became hot, and presently passed into a state of absolute ignition. Various theories have been suggested for its explanation: Mr. Daniell has advanced an opinion which supposes the formation of silicon, and thus accounts for the spontaneous ignition by the action of air.

The disadvantages which arise from the foulness of ships' bottoms, particularly when on foreign stations, where there are no dry docks to receive them, are so serious, that the Government was obliged, in July 1825, to order the discontinuance of the protectors on all sea-going ships; but directed that they should still be used upon all those that were laid up in our ports. When, however, an examination of the latter took place, they were found to be much more foul than those which had been in motion at sea; shell-fish of various kinds had adhered to them so closely that it was even necessary to use percussion to remove them, which not only indented the copper, but in many instances actually fractured it.

Under all these discouraging circumstances, the unwelcome conviction was forced upon the agents of Government, that the plan was incapable of successful application, and it was accordingly altogether abandoned in September 1828.

Such were the results of the experiments carried on in the ports of England, for the protection of copper sheathing; from the success of which Sir H. Davy justly expected honours, fame, and reward:—that his disappointment was great may be readily imagined, and it is supposed to have had a marked influence upon his future character. It is much to be regretted that his vexation should have been heightened by the unjust and bitter attacks made upon him by the periodical press, and by those subalterns in science, who, unable to appreciate the beauty of the principle he had so ably developed, saw only in its details an object for sarcasm, and in its failure an opportunity for censure; while those whose stations should have implied superior knowledge, in the pride and arrogance of assumed contempt, sought a refuge from the humiliation of ignorance.

That Davy was severely hurt by these attacks is a fact well known to his friends. In a letter to Mr. Children he says, "A mind of much sensibility might be disgusted, and one might be induced to say, Why should I labour for public objects, merely to meet abuse?—I am irritated by them more than I ought to be; but I am getting wiser every day—recollecting Galileo, and the times when philosophers and public benefactors were burnt for their services." In another letter he alludes to the sycophancy of a chemical journal, which, after the grossest abuse, suddenly turned round, and disgusted him with its adulation. "I never shake hands," says he, "with chimney sweepers, even when in their May-day clothes, and when they call me '*Your honour*.'"

While the trials above related were proceeding in the ports of England, the naval department of France was prosecuting a similar enquiry; and as experiments of this nature are conducted with greater care, and examined with superior science, in that country, it may not be uninteresting to the English reader to receive a detail of the examination of the bottom of La Constance frigate, in which the protectors bore a much larger proportion to the copper surface than was ever practised in the British navy. This document, I may observe, is now published for the first time.

"The inspection of the bottom of the frigate La Constance, has given rise to some interesting observations on the effect of protectors, and it has confirmed the fact before advanced of the great inconvenience which attends the application of too large a proportion of the protecting metal.

"The surface of this metal, which was of cast iron, placed on each side of the keel, and in long scarphs of iron plates situated towards the stem and stern-post and the water line, appeared to have been about the 1-30th part of the surface of the copper, instead of the 1-250th part as now practised.

"The galvanic action has been extreme, both in rapidity and intensity. The scarphs are entirely destroyed, and have absolutely disappeared; and we should have been ignorant of their having ever existed, had we not been informed of the fact, and observed dark stains which marked their position, and discovered the nails still entire by which they had been fastened.

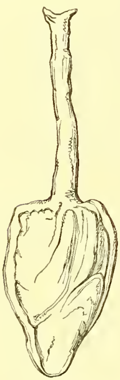
"The plates, which were, in the first instance, about three inches thick, were covered throughout their whole length by a thick, unequal coating, spotted with yellow oxide. This was principally owing to the absorption of about twenty-five per cent. of its weight of water. Under this, the iron was as soft as plumbago, and there remained scarcely an inch of metal of its original metallic hardness.

"The bulky and irregular appendage (the protectors) at the lower part of the ship's bottom caused a great noise in the sea, in consequence of the dead water which it occasioned, and doubtless lessened the speed of the vessel. But that which contributed most to this unfortunate result, was the exceedingly unclean state of the copper, arising from the excess of the iron employed: this, carried to so great an extent, having the effect of extracting matter from the water, which, forming a concretion on the sheets, enabled the marine animals the more easily to attach themselves. The sheathing was covered with a multitude of *lepas anatifera*, shells with five valves, suspended by a pedicle of three or four centimetres long, collected into groups; of *lepas tintinnabulum*, a shell with six valves; of oysters with *opercula;* of *polypi*, &c. No part of the bottom was free from them.

" Below, the copper was certainly preserved from oxidation; and up to within a few sheets of the water line, it did not appear to be worn. But to save expense, it was obliged to be cleansed without removal, by rubbing it hard with bricks and wet sand, which has succeeded very well in restoring it's copper colour."

The following is the description of shells above enumerated:—

Fig. 1.



Genus *Anatifa*, Encyclopedia.—(*Lepas*, Linnæus.)

Fig. 1. Smooth *Anatifa* (*Lepas anatifera*, Linn.)—Shell consisting of five valves, of which two larger and two smaller ones are opposite to each other, and a fifth, which is narrow, is arched and rests upon the ends of the first four; these valves are not connected by any hinge; they are held together by the skin of the animal which lines their interior and opens in front by a longitudinal separation. Their colour is orange during the life of the animal. The base of the shell is united to a fleshy tube, tendinous, cylindrical, susceptible of contraction, saffron-coloured, becoming brown and black in drying.

Fig. 2.

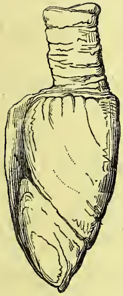


Fig. 2. Smooth *Anatifa*, as seen from the other side, the pedicle dry and contracted.

Fig. 3.

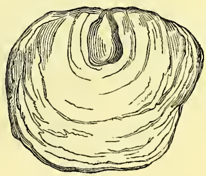
Fig. 3. Smooth *Anatifa*, as seen in front, showing the longitudinal separation.

Genus *Anomia.*

Shell with valves, unequal, irregular, having an operculum; adhering by its operculum; valve usually pierced, flattened, having a cavity in the upper part; the other valve a little larger, concave, entire; operculum small, elliptical, bony, fixed on some foreign body, and to which the interior muscle of the animal is attached.

Species, Onion-peel *Anomia.* — (*Ephippium*, Linn.)

Shell common, whitish and yellowish, found in the Mediterranean and the ocean.

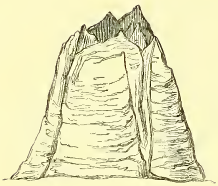


Besides the abovementioned species, which were found in large quantities, there were also some muscles and oysters. — (*Mytilus afer. Baccina.*—Linn. Gmel. 3358.)

Genus "*Balane de Blainville.*" — (*Balanite,* Encyclopedia.—*Lepas,* Linn.)

Fig. 1. Tulip Balanus.—(*Lepas tintinnabulum,* Linn.)

Fig. 1.



Shell with six unequal valves articulated by a scaly suture, of which the edges appear to be finely crenellated in the cavity; the form of the valves is conical, aperture ample, and nearly quadrangular.

Operculum composed of four triangular pieces crenellated and marked with very projecting transverse striæ, which appear to extend from the top to the bottom; the two posterior pieces are perpendicular, and are applied to the hinder partition of the cavity of the shell; they are terminated by two conical prolongations, of which the points are sharp and diverging. The two foremost pieces are placed in the aperture, in an oblique direction. The colour of this balanus from clear red to violet and brown.

Fig. 2.

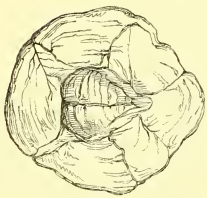


Fig. 2. View of the upper part of the Tulip Balanus.

Fig. 3.

Fig. 3. View of the base.

Fig. 4.

Genus Oyster, (*Ostrea.*)

Fig. 4. Species of oyster, nearly similar to the common oyster, (*Ostrea edulis*,) and of the Huître cuilier, (*Ostrea cochlear*,) their shell rather fragile, almost without lamellæ; upper valve concave, colour rather deep violet, form variable.

"Besides these three kinds of Molluscæ, of which the number was considerable, several species of calcareous polypi were found; but those which could be obtained were too imperfect to allow of their being correctly described.

"The iron which was used to protect the copper on the bottom of the Constance frigate having been subjected to chemical analysis, the following are the results.

"This iron, which was in small fragments, very friable, little attracted by the loadstone, soft to the touch, and soiling the fingers like plumbago, gave out in rubbing it a very strong smell, very much like that of burnt linseed oil. Its colour on the exterior was a brownish yellow, and its interior a blackish grey, studded with little points extremely brilliant.

"A short time after they had been taken from the keel of the frigate, where they were covered with a layer of hydrated peroxide of iron, of six or eight lines in thickness, and been enclosed in a paper box, these fragments became strongly heated, and underwent a real combustion by means of the oxygen of the atmosphere; the combustion was accompanied by the production of a certain quantity of aqueous vapour.

"In order to ascertain whether this elevation of temperature was really alone owing to the absorption of the oxygen, a case containing twelve *grammes* of this iron was placed under a receiver, which contained two hundred millimetres, inverted over a tube of mercury; and it was observed, in the course of an hour, that this air had diminished by forty millimetres, or one-fifth of its volume. Examining afterwards that which remained in the receiver, it was discovered that it had no effect whatever either on lime-water or the tincture of *tournesol,*—that it was not inflammable,—that it extinguished a candle; in a word, that it presented all the negative qualities of azotic gas, strongly infected with the smell before stated.

"It must be evident that the oxygen which was absorbed in this experiment was employed solely in burning the iron, which was already in a state of *protoxide,* as was indicated by its little degree of cohesion, by the avidity with which it seized this principle, and by its dissolving in sulphuric acid, which operated without effervescence, and without disengaging hydrogen gas.

"Five *grammes* of this oxidized iron being reduced to an impalpable powder, and then made red-hot in a platina crucible, and mixed with three parts of *potasse à l'alcool,* were reduced to a clammy mass, coloured on its edges with a clear beautiful green, and with a greenish yellow on the other parts; which at once indicated the presence of a small portion of manganese, and that of a little *chrôme;* metals which are found united in almost all sorts of iron. Treated in the usual way, this mass exhibited—

"First, Traces, scarcely sensible, of these two metals.

"Secondly, One *gramme* of brilliant black powder, soft to the touch, staining paper, insoluble in muriatic acid when applied boiling, it was therefore a true percarburet of iron.

"Thirdly, Three *grammes* and ten *decigrammes* of peroxide of iron.

"On being subjected to the action of boiling water, five grammes of this pulverized iron gave out three *decigrammes* of soluble matter, composed, for the greater part, of *hydrochlorate* of iron, and a trace of hydrochlorate of magnesia, together with a little organic matter, the combination of which with the iron will account for the insufferable smell which it gave out when the iron was heated. This saline solution sensibly reddened the litmus paper; an effect which was owing to the muriatic acid, which, in uniting with oxidized iron, and with most other metallic oxides, never forms combinations which are perfectly neutral, but which are always more or less acid.

"It has in vain been attempted to discover in this oxidized iron the presence of silex, of alumine, and of the sulphuric and carbonic acids, either free or in combination.

"It results from this analysis, that the fragments of the protectors, which have been the object of it, are composed, in a hundred parts, of about

64 oxidized iron,

20 of plumbago, or percarburet of iron,

6 of matter soluble in water, hydrochlorate of magnesia, hydrochlorate of iron, hydrochlorate of soda, hydrochlorate of magnesia, and organic matter, and

10 of water; as in fragments pulverised and heated for half an hour at a temperature of 100°, they lost 1-10th of their weight.

"As to the reddish yellow matter, with small protuberances like nipples, which formed a thick layer on the surface of the protectors, it was formed of 75 parts of oxide of iron at the most, and 25 parts of water, besides some atoms of hydrochlorate of iron, hydrochlorate of soda, and hydrochlorate of magnesia."

Had not the health of Davy unfortunately declined at the very period when his energies were most required, such is the unbounded confidence which all must feel in his unrivalled powers of vanquishing practical difficulties, and of removing the obstacles which so constantly thwart the applications of theory, that little doubt can be entertained but he would soon have discovered some plan by which the adhesion of marine bodies to the copper sheathing might have been prevented, and his principle of Voltaic protection thus rendered available. An experiment indeed, altogether founded upon this same principle, has been already proposed, and will be shortly tried in the British navy, by building a schooner, and fastening its materials together with copper bolts, and afterwards sheathing the bottom with thin plates of iron, which are to be protected by bands of zinc. At the same time, another schooner is to be built, in which the fastenings are to consist entirely of iron bolts and nails, the former to be protected by a zinc ring under each head or clench, and the latter to have a small piece of zinc soldered under its head.

This plan of protection was first adopted in America, at the recommendation of Dr. Riviere; and upon its successful issue, that gentleman was lately induced to take out letters patent not only in England, but in all the maritime countries of Europe, for the sole right of manufacturing iron sheathing, bolts, and nails, thus protected.

As no doubt now exists as to the principle of the protection of iron by zinc, the bolts and nails may be expected to remain free from rust as long as the more oxidable metal lasts; but with regard to the success of the iron sheathing, it is impossible to entertain the same confidence; for what, in this case, is to prevent the adhesion of shell-fish and sea-weed upon its surface? Let it be remembered, that it is only when the copper is in the act of solution in sea water that the sheathing remains clean. In the year 1829, the Tender to the Flag-ship at Plymouth had her copper on one side of the bottom painted with white lead; in six months, this side was covered with long weeds, while the other side, which had been left bright, and consequently exposed to the solvent action of the salt water, was found entirely free from all such adhesions.

CHAPTER XIV.

The failure of the Ship protectors a source of great vexation to Davy. – His Letters to Mr. Poole.—He becomes unwell.—He publishes his Discourses before the Royal Society.—Critical Remarks and Quotations.—He goes abroad in search of health.—His Letter to Mr. Poole from Ravenna.—He resigns the Presidency of the Royal Society.—Mr. Gilbert elected *pro tempore*.—Davy returns to England, and visits his friend Mr. Poole.—Salmonia, or Days of Fly-fishing.—An Analysis of the Work, with various extracts to illustrate its character.

The friends of Sir Humphry Davy saw with extreme regret that the failure of his plan for protecting copper sheathing had produced in his mind a degree of disappointment and chagrin wholly inconsistent with the merits of the question; that while he became insensible to the voice of praise, every nerve was jarred by the slightest note of disapprobation. I apprehend, however, that the change of character which many ascribed to the mortification of wounded pride, ought in some measure to be referred to a declining state of bodily power, which had brought with it its usual infirmities of petulance and despondency. The letters I shall here introduce may perhaps be considered as indicating that instinctive desire for quiet and retirement which frequently marks a declining state of health, and they will be followed by others of a less equivocal character.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Grosvenor Street, November 24, 1824.

It is very long since I have heard from you. Mr. A——, whom you introduced to me, has sometimes given me news of you, and I have always heard of your health and well-being with pleasure.

My immediate motive for writing to you now is somewhat, though not entirely, selfish. You know I have always admired your neighbourhood, and I have lately seen a place advertised there, called, I think, ———, not far from Quantock, and combining, as far as advertisement can be trusted, scenery, fishing, shooting, interest for money, &c.

If it is not sold, pray give me a little idea of it; I have long been looking out for a purchase,—perhaps this may suit me. After all, it may be sold; if so, no harm is done.

I go on labouring for utility, perhaps more than for glory; caring something for the judgment of my contemporaries, but more for that of posterity; and confiding with boldness in the solid judgment of Time.

I have lately seen some magnificent country in the Scandinavian peninsula, where Nature, if not a kind, is at least a beautiful mother.—I wonder there have not been more poets in the North.

I am, my dear Poole,

Very affectionately your old friend,

H. Davy.

TO THE SAME.

MY DEAR POOLE, January 5, 1825.

My proposition to come into Somersetshire about the 10th was founded upon two visits which I had to pay in this county, Hants; I am now only about sixty miles from you; and had you been at home, I should have come on to Nether Stowey. The 13th is the first meeting of the Royal Society after the holidays; and though I might do my duty by deputy, yet I feel that this would not be right, and I will not have the honour of the chair without conscientiously taking the labours which its possession entails. I regret therefore that I cannot be with you next week.

God bless you. Believe me always, my dear Poole,

Your affectionate friend,

H. Davy.

TO THE SAME.

MY DEAR POOLE, Park Street, Feb. 11, 1825.

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I had a letter a few days ago from C——, who writes in good spirits, and who, being within a few miles of London, might, as far as his friends are concerned, be at John a Grot's house. He writes with all his ancient power. I had hoped that, as his mind became subdued, and his imagination less vivid, he might have been able to apply himself to persevere, and to give to the world some of those trains of thought, so original, so impressive, and at which we have so often wondered.

I am writing this letter at a meeting of the Trustees of the British Museum, which will account for its want of correction. Lest I should be more desultory, I will conclude by subscribing myself, my dear Poole,

Your old and affectionate friend,

H. Davy.

TO THE SAME.

MY DEAR POOLE, Feb. 28, 1825.

I am very much obliged to you for your two letters, which I received in proper time. I have deferred writing, in the hopes that I might be able to pay you a visit and see the property, but I now find this will be impossible. I have a cold, which has taken a stronger and more inflammable character than usual, which obliges me to lay myself up ; and in this weather it would be worse than imprudent to travel.

I have seen Mr. Z———, and can perfectly re-echo your favourable sentiments respecting him. I saw the plan of the estate, and heard every thing he had to say respecting the value, real and imaginary, of the lands. He certainly hopes at this moment for a fancy price, and he is right if he can get it.

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I have less fancy for the place, from finding the trout stream a brook in summer, where salmon-trout, or salmon, could not be propagated ; for one of my favourite ideas in a country residence is varied and multiplied experiments on the increase and propagation of fish.

What I should really like would be a place with a couple of hundred acres of productive land, and plenty of moor, a river running through it, and the sea before it; and not farther from London than Hampshire—a day's journey. There are such places along the coast, though perhaps in my lifetime they will not be disposed of. I should also like to be within a few miles of you ; for it is one of the regrets in the life which I lead, that devotion to the cause of science separates me very much from friends that I shall ever venerate and esteem. God bless you, my dear Poole.

Very affectionately yours,

H. Davy.

TO THE SAME.

MY DEAR POOLE, Pixton near Dulverton, Nov. 1, 1826.

I cannot be in your neighbourhood, without doing my best to see you; and it is my intention to come to Stowey on Sunday. I hope I shall find you at home, and quite well.

Mr. T——, who is here, gives me a very good account of you, which I trust I shall be personally able to verify.

If you are at leisure, I will try to shoot a few woodcocks on Monday on the Quantock hills; on Tuesday I must go east.

I have not been well lately. I cannot take the exercise which twenty years ago I went lightly and agreeably through. Will you have the kindness to hire a pony for me, that I may ride to your hills?

I am sorry I did not know of your journey to Ireland and Scotland. I was in both those countries at the time you visited them, and should have been delighted to have met you.

Do not write to me, for, even if you should not be at home, Stowey is not more than ten or twelve miles out of my way; but I hope I shall find you. I am, my dear Poole,

Your old and sincere friend,

H. Davy.

The complaints, as to the loss of his strength, which are expressed in the preceding letter, were but too well founded. Mr. Poole informs me that, during this visit in 1826, it was affecting to observe the efforts he made to continue his field sports. From being unable to walk without fatigue, he was compelled to have a pony to take him to the field, from which he dismounted only on the certainty of immediate sport.

On his return to London, his indisposition increased: he complained to me of palpitation of the heart, and of an affection in the trachea, which led him to fear that he might be suffering under the disease of which his father died.

The fatigue attendant upon the duties of the anniversary of the Royal

Society (November 30th) completely exhausted him; and after his re-election as President, he was reluctantly obliged to retire, and to decline attending the usual dinner upon that occasion.

In January 1827, Sir Humphry Davy published the Discourses which he had delivered before the Royal Society, at six successive anniversary meetings, on the award of the Royal and Copley medals. They were published in compliance with a resolution of a meeting of the Council, held on the 21st of December 1826.

The practice of delivering an annual oration before the Royal Society, on the occasion of presenting the medal upon Sir Godfrey Copley's donation, prevailed during the presidency of Sir John Pringle; it was, however, during a long interval discontinued, and only revived during the latter years of Sir Joseph Banks.

The discourse usually commenced with a short tribute of respect to the memory of those distinguished Fellows who had died since the preceding anniversary. It then proceeded to announce the choice of the Council in its award of the medals, enumerating the objects and merits of the several communications which had been honoured with so distinguished a mark of approbation, and stating the circumstances which had directed the judges in their decision.

Much has been said and written upon the inutility, and even upon the mischievous tendency of this practice; and great stress has been laid upon the vices inseparably connected, as it is asserted, with the style of composition to which it gives origin. It appears to me, however, that it is only against the meretricious execution, not against the temperate use of such discourses, that this charge can be fairly and consistently sustained; and in the chaste and yet powerful addresses of Davy, such an opinion will find its best sanction, and obtain its strongest support.

Does it follow, because praise, when unduly lavished upon the labours of the scientific dead, may create comparisons and preferences injurious to the living, that we are to stifle the noblest aspirations of our nature, and become as cold and silent as the grave that encloses their remains? Does it follow, because an undisciplined ardour may have occasionally exaggerated the merits of our contemporaries, that we are henceforth to withhold from them a just tribute of applause at their discoveries—to forego the advantages which science must derive from a plan so well calculated to awaken the flagging attention, to infuse into stagnant research a renewed spirit of animation, and to encourage the industry of the labourer in the abstract regions of science, with prospects gleaming with sunshine, and luxuriant in the fruitfulness which is to reward him?

Such was the character, such the effect of Davy's discourses. They exhibit a great assemblage of diversified talents, and display the refined views he entertained with respect to the mutual relations which the different sciences maintain with each other; they evince, moreover, a great command of language, and a power to give exact expression to what his mind had conceived.

To these six Discourses is prefixed his Address upon taking the chair of the Royal Society for the first time; the subject of which is "The present state of that Body, and the Progress and Prospects of Science." Upon this occasion, he particularly adverts to the light which the different branches of science may reflect upon each other. "In pure Mathematics—though their nature, as a work of intellectual combination, framed by the highest efforts of human intelligence, renders them incapable of receiving aids from observations of external phenomena, or the invention of new instruments, yet they are, at this moment, abundant in the promise of new applications; and many of the departments of philosophical enquiry which appeared formerly to bear no relation to quantity, weight, figure, or number, as I shall more particularly mention hereafter, are now brought under the dominion of that sublime science, which is, at it were, the animating principle of all the other sciences."

"In the theory of light and vision, the researches of Huygens, Newton, and Wollaston, have been followed by those of Malus; and the phenomena of polarization are constantly tending to new discoveries; and it is extremely probable that those beautiful results will lead to a more profound knowledge than has hitherto been obtained, concerning the intimate constitution of bodies, and establish a near connexion between mechanical and chemical philosophy."

"The subject of heat, so nearly allied to that of light, has lately afforded a rich harvest of discovery: yet it is fertile in unexplored phenomena. The question of the materiality of heat will probably be solved at the same time as that of the undulating hypothesis of light, if, indeed, the human mind should ever be capable of understanding the causes of these mysterious phenomena. The applications of the doctrine of heat to the atomic or corpuscular philosophy of chemistry abound in new views, and probably at no very distant period these views will assume a precise mathematical form."

"In Electricity, the wonderful instrument of Volta has done more for the obscure parts of physics and chemistry, than the microscope ever effected for natural history, or even the telescope for astronomy. After presenting to us the most extraordinary and unexpected results in chemical analysis, it is now throwing a new light upon magnetism.

'Suppeditatque novo confestim lumine lumen.'

"I must congratulate the Society on the rapid progress made in the theory of definite proportions, since it was advanced in a distinct form by the ingenuity of Mr. Dalton. I congratulate the Society on the promise it affords of solving the recondite changes, owing to motions of the particles of matter, by laws depending upon their weight, number, and figure, and which will be probably found as simple in their origin, and as harmonious in their relations, as those which direct the motions of the heavenly bodies, and produce the beauty and order of the celestial systems.

"The crystallizations, or regular forms of inorganic matter, are intimately connected with definite proportions, and depend upon the nature of the combinations of the elementary particles; and both the laws of electrical polarity, and the polarization of light, seem related to these phenomena. As to the origin of the primary arrangement of the crystalline matter of the globe, various hypotheses have been applied, and the question is still agitated, and is perhaps above the present state of our knowledge; but there are two principal facts which present analogies on the subject,—one, that the form of the earth is that which would result, supposing it to have been originally fluid; and the other, that in lavas, masses decidedly of igneous origin, crystalline substances, similar to those belonging to the primary rocks, are found in abundance."

It is the privilege of genius to be in advance of the age, and to see, "as by refraction, the light, as yet below the horizon." It is with such a feeling that I have introduced the foregoing extracts, which I cannot but regard as prophetic of future discoveries.

The first discourse was delivered on the 30th of November 1821, on the occasion of announcing the award of two medals, on Sir Godfrey Copley's donation; one to J. F. W. Herschel, Esq. for his various papers on mathematical and physico-mathematical subjects; and the other, to Captain Edward Sabine, R.A., for his papers containing an account of his various experiments and observations made during a voyage and expedition in the Arctic regions.

As I am desirous that the reader should be made acquainted with the nature and style of the address with which he accompanied the presentation of the medal, I cannot select a happier example, or one in the sentiments of which every person will more readily participate, than the following:—

"Mr. Herschel —Receive this medal, Sir, as a mark of our respect, and of our admiration of those talents which you have applied with so much zeal and success, and preserve it as a pledge of future exertions in the cause of Science and of the Royal Society; and, believe me, you can communicate your labours to no public body by whom they will be better received, or through whose records they will be better known to the philosophical world. You are in the prime of life, in the beginning of your career, and you have powers and acquirements capable of illustrating and extending every branch of physical enquiry; and, in the field of science, how many are the spots not yet cultivated! Where the laws of sensible become connected with those of insensible motions, the mechanical with the chemical phenomena, how little is known! In electricity, magnetism, in the relations of crystallized forms to the weight of the elements of bodies, what a number of curious and important objects of research! and they are objects which you are peculiarly qualified to pursue and illustrate.

"May you continue to devote yourself to philosophical pursuits, and to exalt your reputation, already so high—

'Virtutem extendere factis.'

And these pursuits you will find not only glorious, but dignified, useful, and gratifying in every period of life: this, indeed, you must know best in the example of your illustrious father, who, full of years and of honours, must view your exertions with infinite pleasure; and who, in the hopes that his own imperishable name will be permanently connected with yours in the annals of philosophy, must look forward to a double immortality."

In the discourse of the succeeding year, it was his painful duty to announce the death of the elder Herschel, whom, in his former address, he had eulogized in such eloquent and touching language.

In alluding to the labours and discoveries of Sir William Herschel, he observed, that "they have so much contributed to the progress of modern astronomy, that his name will probably live as long as the inhabitants of this earth are permitted to view the solar system, or to understand the laws of its motions. The world of science—the civilized world, are alike indebted to him who enlarges the boundaries of human knowledge, who increases the scope of intellectual enjoyment, and exhibits the human mind in possession of new and unknown powers, by which it gains, as it were, new dominions in space; acquisitions which are imperishable—not like the boundaries of terrestrial states and kingdoms, or even the great monuments of art, which, however extensive and splendid, must decay—but secured by the grandest forms and objects of nature, and registered amongst her laws."

One more quotation, and I shall conclude with the conviction that the splendid specimens I have adduced must fully justify the opinion already offered as to the taste, power, and eloquence with which, as President of the Royal Society, he discharged the most delicate and arduous of all its duties.

In his address to Mr. (now Dr.) Buckland, on delivering to him the medal for his important memoir on the fossile remains discovered in the cave near Kirkdale, he thus concludes:—"If we look with wonder upon the great remains of human works, such as the columns of Palmyra, broken in the midst of the desert; the temples of Pæstum, beautiful in the decay of twenty centuries; or the mutilated fragments of Greek sculpture in the Acropolis of Athens, or in our own Museum, as proofs of the genius of artists, and power and riches of nations now past away; with how much deeper a feeling of admiration must we consider those grand monuments of nature which mark the revolutions of the globe—continents broken into islands; one land produced, another destroyed; the bottom of the ocean become a fertile soil; whole races of animals extinct, and the bones and exuviæ of one class covered with the remains of another; and upon these graves of past generations—the marble or rocky tombs, as it were, of a former animated world, new generations rising, and order and harmony established, and a system of life and beauty produced, as it were, out of chaos and death, proving the infinite power, wisdom, and goodness of the Great Cause of all being!"

I have noticed the apparent commencement of that general indisposition which had for some time been stealing upon him, undermining his powers, oppressing his spirits, and subduing his best energies; but in the end of 1826, his complaint assumed a more decided and alarming form. Feeling more than usually unwell, while on a visit to his friend Lord Gage, he determined to return to London, and was seized while on his journey, at Mayersfield, with an apoplectic attack. Prompt and copious bleeding, however, on the spot, arrested the symptoms more immediately threatening the extinction of life, and enabled him to reach home; but paralysis, the usual consequence of such seizures, had obviously, though at first but slightly, diminished his muscular powers, and given an awkwardness to his gait.

As soon as the more immediate danger of the attack had passed away, it was thought expedient to recommend, as the best means of his farther recovery, a residence in the southern part of Europe, where he would be removed from all the cares and anxieties that were inseparably connected with his continuance in London; and he accordingly quitted England, with the intention of spending what remained of the winter in Italy.

The following interesting letter to his friend will sufficiently explain the serious character of his malady, and the degree of bodily infirmity which accompanied it.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Ravenna, March 14, 1827.

I SHOULD have answered your letter immediately, had it been possible; but I was, at the time I received it, very ill, in the crisis of the complaint under which I have long suffered, and which turned out to be a determination of the blood to the brain; at last producing the most alarming nervous symptoms, and threatening the loss of power and of life.

Had I been in England, I should gladly have promoted the election of your friend at the Athenæum: your certificate of character would always be enough for me; for, like our angling evangelical Isaac Walton, I know you choose for your friends only good men.

I am, thank God, better, but still very weak, and wholly unfit for any kind of business and study. I have, however, considerably recovered the use of all the limbs that were affected; and as my amendment has been slow and gradual, I hope in time it may be complete: but I am leading the life of an anchorite, obliged to abstain from flesh, wine, business, study, experiments, and all things that I love; but this discipline is salutary, and for the sake of being able to do something more for science, and, I hope, for humanity, I submit to it; believing that the great source of intellectual being so wills it for good.

I am here lodged in the Apostolical Palace, by the kindness of the Vice-Legate of Ravenna, a most admirable and enlightened prelate, and who has done every thing for me that he could have done for a brother.

I have chosen this spot of the declining empire of Rome, as one of solitude and repose, as out of the way of travellers, and in a good climate; and its monuments and recollections are not without interest. Here Dante composed his divine works. Here Byron wrote some of his best and most moral (if such a name can be applied) poems; and here the Roman power that began among the mountains with Romulus, and migrated to the sea, bounding Asia and Europe under Constantine, made its last stand, in the marshes formed by the Eridanus, under Theodorick, whose tomb is amongst the wonders of the place.

After a month's travel in the most severe weather I ever experienced, I arrived here on the 20th of February. The weather has since been fine. My brother and friend, who is likewise my physician, accompanied me; but he is so satisfied with my improvement, as to be able to leave me for Corfu; but he is within a week's call.

I have no society here, except that of the amiable Vice-Legate, who is the Governor of the Province; but this is enough for me, for as yet I can bear but little conversation. I ride in the pine forest, which is the most magnificent in Europe, and which I wish you could see. You know the trees by Claude Loraine's landscapes; imagine a circle of twenty miles of these great fan-shaped pines, green sunny lawns, and little knolls of underwood, with large junipers of the Adriatic in front, and the Apennines still covered with snow behind. The pine wood partly covers the spot where the Roman fleet once rode,—such is the change of time!

It is my intention to stay here till the beginning of April, and then to go to the Alps, for I must avoid the extremes of heat and cold.

God bless you, my dear Poole. I am always your old and sincere friend,

H. Davy.

Feeling that his recovery was tardy, and that perfect mental repose was more than ever necessary for its advancement, he determined to resign the chair of the Royal Society; and he accordingly announced that intention, by a letter to his friend, Mr. Davies Gilbert, Vice-President of the Society.

TO DAVIES GILBERT, ESQ. M. P. V. P. R. S. &c. &c.

MY DEAR SIR, Salzburgh, July 1, 1827.

YESTERDAY, on my arrival here, I found your two letters. I am sorry I did not receive the one you were so good as to address to me at Ravenna; nor can I account for its miscarriage. I commissioned a friend there to transmit to me my letters from that place after my departure, and I received several, even so late as the middle of May, at Laybach, which had been sent to Italy, and afterwards to Illyria. I did not write to you again, because I always entertained hopes of being able to give a better account of the state of my health. I am sorry to say the expectations of my physicians of a complete and rapid recovery have not been realized. I have gained ground, under the most favourable circumstances, very slowly; and though I have had no new attack, and have regained, to a certain extent, the use of my limbs, yet the tendency of the system to accumulate blood in the head still continues, and I am obliged to counteract it by a most rigid vegetable diet, and by frequent bleedings with leeches and blisterings, which of course keep me very low. From my youth up to last year, I had suffered, more or less, from a slight hemorrhoidal affection; and the fulness of the vessels, then only a slight inconvenience, becomes a serious and dangerous evil in the head, to which it seems to have been transferred. I am far from despairing of an ultimate recovery, but it must be a work of time, and the vessels which have been over distended only very slowly regain their former dimensions and tone: and for my recovery, not only diet and regimen and physical discipline, but a freedom from anxiety, and from all business and all intellectual exertion, is absolutely required.

Under these circumstances, I feel it would be highly imprudent and perhaps fatal for me, to return, and to attempt to perform the official duties of President of the Royal Society. And as I had no other feeling for that high and honourable situation, except the hope of being useful to society, so I would not keep it a moment without the security of being able to devote myself to the labour and attention it demands. I beg therefore you will be so good as to communicate my resignation to the Council and to the Society at their first meeting in November, after the long vacation; stating the circumstances of my severe and long continued illness, as the cause. At the same time, I beg you will express to them how truly grateful I feel for the high honour they have done me in placing me in the chair for so many successive years. Assure them that I shall always take the same interest in the progress of the grand objects of the Society, and throughout the whole of my life endeavour to contribute to their advancement, and to the prosperity of the body.

Should circumstances prevent me from sending, or you from receiving any other communication from me before the autumn (for nothing is more uncertain than the post in Austria, as they take time to read the letters), I hope this, which I shall go to Bavaria to send, will reach you safe, and will be sufficient to settle the affair of resignation.

It was my intention to have said nothing on the subject of my successor. I will support by all the means in my power the person that the leading members of the Society shall place in the chair; but I cannot resist an expression of satisfaction in the hope you held out, that an illustrious friend of the Society, illustrious from his talents, his former situation, and, I may say, his late conduct, is likely to be my successor.

I wish my name to be in the next Council, as I shall certainly return, *Deo volente*, before the end of the Session, and I may I think be of use; and likewise, because I hope it may be clearly understood that my feelings for the Society are, as they always were, those of warm attachment and respect. Writing still makes my head ache, and raises my pulse. I will therefore conclude, my dear Sir, in returning you my sincere thanks for the trouble you have had on my account, and assuring you that I am

Your obliged and grateful friend and servant,

H. Davy.

Pray acknowledge the receipt of this letter, by addressing me, "*poste restante*, Laybach, Illyria, Austria;" and let me know if Mr. Hudson is still Assistant-Secretary, and where Mr. South is. I send this letter from Frauenstein, Bavaria, July 2, that it may not be opened, as all my letters were at Salzburgh. There was one of them must have *amused* Prince Metternich, on the state of parties in England, from a Member of the Upper House.

In consequence of this letter, the Council of the Royal Society, by a resolution passed at a very full meeting held on the 6th of November, 1827, appointed Mr. Davies Gilbert to fill the chair, until the general body should elect a President, at the ensuing anniversary.

The following letter will show his subsequent course of proceeding.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Park Street, Grosvenor Square, Oct. 29, 1827.

I HOPE you received a letter which I addressed to you from Ravenna in the spring. It was my intention to have returned to Italy from the Alpine countries, where I spent the summer; but my recovery has been so slow, and so much uneasiness in the head and weakness in the limbs remained in September, that I thought it wiser to return to my medical advisers in London.

I have consulted all the celebrated men who have written upon or studied the nervous system. They all have a good opinion of my case, and they all order absolute repose for at least twelve months longer, and will not allow me to resume my scientific duties or labours at present; and they insist upon my leaving London for the next three or four months, and advise a residence in the west of England. Now, my dear friend, you recollect our conversation upon the subject of a residence—I think Mr. C.'s is not very far from you. Pray let me know something on this head. I want very little of any thing, for I am almost on a vegetable diet; and a little horse exercise, a very little shooting, and a little quiet society, are what I am in search of, with some facilities of procuring books. I have thought of Minehead, Ilfracombe, Lymouth, and Penzance; but I have not yet determined the point.

Horse exercise and shooting are necessary to bring back my limbs to their former state, and therefore Bath and Brighton will not do for me. God bless you, my dear Poole, and pray let me hear from you.

Your affectionate,

H. DAVY.

P.S. I hope you got the copy of my discourses.

TO THE SAME.

MY DEAR POOLE, Firle, near Lewes, November 4, 1827.

I HAVE this moment received your very kind and most friendly letter. I have made my first visit to my friend Lord G——, where I was taken ill last year, and have borne the journey well, and have enjoyed the small society here; but I am very weak indeed, and I cannot yet walk more than a mile. One of three plans, I shall hope to adopt; two of them you have most amiably suggested, the other is to go to Penzance. My only objection to the last is the fear of too much society. Whatever I do, I will first come to you and take your advice.

When I returned, I had little hopes of recovery; but the assurances of my physicians that I may again, with care, be re-established, have revived me, and I have certainly gained ground, and gained strength, by the plan I am now pursuing.

As soon as I return to London, I will write to you. If I can find a companion, I think Mr. C———'s house will do admirably; but I must see it, as a temperate situation is a *sine quâ non.*

I need not say how grateful I am for your kindness, and if I recover, how delighted I shall be to owe the means to so excellent and invaluable a friend. God bless you. I am, my dear Poole, your affectionate,

H. Davy.

TO THE SAME.

MY DEAR POOLE, Firle, Nov. 7.

I am going to London to-morrow, and after staying two or three days, to try a new plan of medical treatment, which my physicians recommend, I shall come westward, and profit by your kindness, and adopt whichever of the plans will promise to be most salutary.

If I take Mr. C———'s house, Lady Davy will come to me. With respect to society, I want only a friend, or one person or two at most, to prevent entire solitude, and I am too weak to bear much conversation, and wholly unfit to receive any but persons with whom I am in the habits of intimacy.

I can hardly express to you how deeply I feel your kindness.

* * * * * * *

As I must travel slowly, I shall not probably be at Stowey before Wednesday or Thursday next. Pray do not ask any body to meet me. I am upon the *strictest* diet,—a wing of a chicken and a plain rice or bread pudding is the extreme of my *gourmanderie.* God bless you.

My dear Poole, your affectionate friend,

H. Davy.

Mr. Poole has been so obliging as to communicate to me some interesting particulars connected with the visit to which the foregoing letters allude.

" During this last visit, (November and December 1827,) his bodily infirmity was very great, and his sensibility was painfully alive on every occasion. Unhappily, he had to sustain the affliction of the sudden death of Mr. R——, the son of a friend whom he highly valued; and though this afflicting event was, by the considerate and anxious attention of Lady Davy, first communicated to me by letter, to be imparted to him with every precaution, to avoid his being suddenly shocked, yet it was many days before he could recover his usual spirits, feeble as they were, and resume his wonted occupation.

" On his arrival, he said, ' Here I am, the ruin of what I was;' but nevertheless, the same activity and ardour of mind continued, though directed to different objects. He employed himself two or three hours in the morning on his *Salmonia,* which he was then writing; he would afterwards take a short walk, which he accomplished with difficulty, or ride. After dinner, I used to read to him some amusing book. We were particularly interested by Southey's Life of Nelson. ' It would give Southey,' he said, ' great pleasure, if he knew how much his narrative affected us.'*

" In the evening, Mr. and Mrs. W——, the former of whom he had long known, frequently came to make a rubber at whist. He was averse to seeing strangers; but on being shown the drawings of Natural History of a friend of mine of great talent, Mr. Baker of Bridgwater, he was anxious to know him, and was much pleased with his company. He suggested to him various subjects for investigation, concerning insects, and fish, particularly the eel. What pleasure would it give him were he now alive, to learn the interesting result of those suggestions! I hope the public will soon be made acquainted with them.

" Natural History in general had been a favourite subject with him throughout his protracted illness; and during this last visit to me, he paid attention to that only; ' For,' said he, ' I am prohibited applying, and indeed I am incapable of applying, to any thing which requires severe attention.'

" During the same visit, I remember his inherent love of the laboratory, if I may so express myself, being manifested in a manner which much interested me at the moment. On his visiting with me a gentleman in this neighbourhood, who had offered him his house, and who has an extensive philosophical apparatus, particularly complete in electricity and chemistry, he was fatigued with the journey, and as we were walking round the house very languidly, a door opened, and we were in the laboratory. He threw a glance around the room, his eyes brightened in the action, a glow came over his

* His admiration of this work bursts forth in his *Salmonia,* which he was writing at that time. He styles it " an immortal monument raised by Genius to Valour."

countenance, and he looked like himself, as he was accustomed to appear twenty years ago.

"You are aware that he was latterly a good shot, always an expert angler, and a great admirer of old Isaac Walton; and that he highly prided himself upon these accomplishments. I used to laugh at him, which he did not like; but it amused me to see such a man give so much importance to those qualifications. He would say, 'It is not the sport only, though there is great pleasure in successful dexterity, but it is the ardour of pursuit, pure air, the contemplation of a fine country, and the exercise—all tend to invigorate the body, and to excite the mind to its best efforts.'

"These amusements seemed to become more and more important in his estimation, as his health declined. It was affecting to observe the efforts he made to continue them with diminished strength. From being unable to walk without fatigue for many hours, he was, when he came to me in November 1826, obliged to have a pony to carry him to the field, from which he dismounted only on the certainty of immediate sport. In the following year, he could only take short and occasional rides to the covers, with his dogs around him, and his servant walking by his side, and carrying his gun, but which I believe he never fired."

"During this visit, he more than once observed, 'I do not wish to live, as far as I am personally concerned; but I have views which I could develope, if it pleased God to save my life, which would be useful to science and to mankind.'"

Davy returned to town in December, and after an interval wrote the following letter:

TO THOMAS POOLE, ESQ.

MY VERY DEAR FRIEND, Park Street, Grosvenor Square, Dec. 27, 1827.

I KNOW no reason why I have not written to you. It has been my intention every day, and I have been every day prevented by the sense of want of power, which is so painful a symptom of my malady.

I continue much as I was. My physicians augur well, and I have some repose in the hopes connected with the indefinite future. In the last twelvemonth, which I hope is a large portion, on the whole, of my purgatory expiation for crimes of commission or omission, the most cheerful, or rather the least miserable, days that I spent, were a good deal owing to your kindness, which I shall never forget. I would, if it were possible, make my letter something more than a mere bulletin of health, or the expression of the feelings of a sick man; but I can communicate no news. The papers will tell you more than is true; and our politicians seem ignorant of what they are to do at home, much more abroad.

* * * * * * *

* * * * * * *

I have got for you a copy of my lectures on the Chemistry of Agriculture, which I shall send to you by the first opportunity. God bless you, my dear Poole,

I am always your sincere, grateful, and affectionate friend,

H. Davy.

In the letter which follows, Davy dwells upon a subject in Natural History, which appears to have greatly occupied his thoughts, and to have continued a predominant subject of his contemplation, even to the latest day of his life.

TO THOMAS POOLE, ESQ.

MY DEAR FRIEND, Park Street, January 1, 1828.

I write to you immediately, because that part of your letter which relates to Mr. Baker's pursuits interests me very much: but before I begin on this subject, I will give you a short bulletin of the state of my health. I go on much as I did at Stowey, and my physicians have made no alterations in the plan of treatment: I am not worse, and they tell me I shall be better. Now for Mr. Baker—I am very glad that he is occupied with those enquiries. I am particularly anxious for information on the generation of eels: it is an unsolved problem since the time of Aristotle. I am sure that all eels come from the sea, where they are bred; but there may be one or two species or varieties of them. What Mr. Baker says about the difference between the common eel and the conger is well worthy of attention; but I have known changes more extraordinary than the obliteration, or destruction, of a small tubular member occasioned by difference of habits.

Were the salt-water eels, and the fresh-water eels which he examined of the same size? Many individuals of various sizes should be examined to establish the fact of their specific difference. This would be the season for examining the genital organs of eels, for they breed in winter; and were I a little better, I should go to the sea for the purpose of making enquiries on the subject.

Sir Everard Home is firmly convinced that the animal is hermaphrodite and impregnates itself: this, though possible, appears to me very strange in so large an animal. If Mr. Baker will determine this point, I can promise him an immortality amongst our philosophical anglers and natural historians; and if he will give us the history of water flies, imitated by fly-fishers, he will command our immediate gratitude.

Pray communicate this letter to him with my best wishes, and with my hopes that his talents, which are very great, will be applied to enlighten us.

I can give you no news; the weather is dreadful, and the blacks and yellows are descending in fog. I long for the fresh air of your mountains.

God bless you, my dear Poole. Many—many happy new years to you. Pray remember me, with the compliments of this day, to your excellent neighbours at Stowey. Your affectionate friend,

H. Davy.

TO THE SAME.

MY DEAR POOLE, Park Street, March 26.

Your letter has given me great pleasure; first, because you, who are an enlightened judge in such matters, approve of my humble contribution to agriculture; and, secondly, because it makes me acquainted with your kind feelings, health, and Mr. Baker's interesting pursuits.

Mr. Baker appears to me to have distinctly established the point that the eel and conger are of different species; and from his zeal and activity, I hope the curious problem of the generation of these animals will be solved. I shall expect with impatience the results of his enquiries.—Now for my health, my very dear friend. I wish I could speak more favourably; I certainly do not lose ground, but I am doubtful if I gain any; but I do not despair.

I am going, by the advice of my physicians, to try another continental journey. If I get considerably better, I shall winter in Italy, where, in this case, I shall hope to see you, and where I shall have an apartment ready for you in Rome.

I have not been idle since I left your comfortable and hospitable house. I have finished my *Salmonia*, and sent it to the press.—"*Flumina amo sylvasque inglorius.*"—I do not think you will be displeased with this little *jeu* of my sick hours.

Mr. A—— was very amiable in calling on me. There is nothing that annoys me so much in my illness as my helplessness in not being able to indulge in society.

Your grateful and affectionate friend,

H. Davy.

We will now, for a while, leave our philosopher to pursue his journey to Italy, while we take a review of his Salmonia; the first edition of which was published in the Spring of 1828. The second, and much improved edition,* from which I shall take my extracts, is dated from Laybach, Illyria, September 28, 1828, but which did not appear until 1829.

We are told in the preface, that these pages formed the occupation of the author during some months of severe and dangerous illness, when he was wholly incapable of attending to more useful studies, or of following more serious pursuits;—that they constituted his amusement in many hours, which otherwise would have been unoccupied and tedious;—and that they are published in the hope that they may possess an interest for those persons who derive pleasure from the simplest and most attainable kind of rural sports, and who practise the art, or patronise the objects of contemplation, of the philosophical angler.

He informs us that the conversational manner and discursive style were chosen as best suited to the state of health of the author, who was incapable of considerable efforts and long continued attention; and he adds, that he could not but have in mind a model, which has fully proved the utility and popularity of this method of treating this subject—"The complete Angler," by Walton and Cotton.

The characters chosen to support these conversations, were—Halieus, who is supposed to be an accomplished fly-fisher—Ornither, who is to be regarded as a gentleman generally fond of the sports of the field, though not a finished master of the art of angling—Poietes, who is to be considered as an enthusiastic lover of nature, and partially acquainted with the mysteries of fly-fishing; and Physicus, who is described uninitiated as an angler, but as a person fond of enquiries in natural history and philosophy.

Such are the personages by whose aid the machinery is to be worked; but he tells us that they are of course imaginary, though the sentiments attri-

* "Salmonia, or Days of Fly-fishing; in a series of Conversations; with some account of the habits of Fishes belonging to the genus Salmo. By an Angler. Second edition.—London, John Murray, 1829."

buted to them, the author may sometimes have gained from recollections of real conversations with friends, from whose society much of the happiness of his early life had been derived; and he admits that, in the portrait of the character of HALIEUS, given in the last dialogue, a likeness will not fail to be recognised to that of the character of a most estimable physician, ardently beloved by his friends, and esteemed and venerated by the public.

The work is dedicated to Dr. Babington, "in remembrance of some delightful days passed in his society, and in gratitude for an uninterrupted friendship of a quarter of a century."

I am informed by Lady Davy, that the engravings of the fish, by which the work is illustrated, are from drawings of his own execution; so that he could not, like old Isaac Walton, "take the liberty to commend the excellent pictures to him that likes not the book, because they concern not himself."

It has frequently happened that, while works of deep importance have justly conferred celebrity upon the author, his minor productions have been entirely indebted to his name for their popularity, and to his authority for their value. This, however, cannot be said of Salmonia, for it possesses the stamp of original genius, and bears internal evidence of a talent flowing down from a very high source of intelligence. In a scientific point of view, it exhibits that penetrating observation by which a gifted mind is enabled to extract out of the most ordinary facts and every day incidents, novel views and hidden truths; while it shows that a humble art (I beg pardon of the brothers of the Angle) may, through the skill of the master, be made the means of calling forth the affections of the heart, and of reflecting all the colours of the fancy. By regarding the work in relation to the history and condition of its author, it certainly acquires much additional interest. The familiar and inviting style of the dialogue, whenever he discusses questions of natural history, must convince us that he was as well calculated to instruct in the Lyceum, as we long since knew him to be to teach in the Academy.

Composed in the hour of sickness and prostration, the work displays throughout its composition a tone of dignified morality and an expansion of feeling, which may be regarded as in unison with a mind chastened but not subdued, and looking forward to a better state of existence. "I envy," says he, "no quality of the mind or intellect in others; be it genius, power, wit, or fancy: but if I could choose what would be most delightful, and I believe most useful to me, I should prefer a firm religious belief to every other blessing; for it makes life a discipline of goodness; creates new hopes, when all earthly hopes vanish; and throws over the decay, the destruction of existence, the most gorgeous of all lights; awakens life even in death, and from corruption and decay calls up beauty and divinity; makes an instrument of torture and of shame the ladder of ascent to paradise; and, far above all combinations of earthly hopes, calls up the most delightful visions of palms and amaranths, the gardens of the blest, the security of everlasting joys, where the sensualist and the sceptic view only gloom, decay, annihilation, and despair!"

While describing an animated scene of insect enjoyment, he bursts into an apostrophe, highly characteristic of that quick and happy talent for seizing analogies, which so eminently distinguished all his writings. I shall quote the passage.

"*Physicus.*—Since the sun has disappeared, the cool of the evening has, I suppose, driven the little winged plunderers to their homes; but see, there are two or three humble bees which seem languid with the cold, and yet they have their tongues still in the fountain of honey. I believe one of them is actually dead, yet his mouth is still attached to the flower. He has fallen asleep, and probably died whilst making his last meal of ambrosia.

"*Ornither.*—What an enviable destiny, quitting life in the moment of enjoyment, following an instinct, the gratification of which has been always pleasurable! so beneficent are the laws of Divine Wisdom.

"*Physicus.*—Like Ornither, I consider the destiny of this insect as desirable, and I cannot help regarding the end of human life as most happy, when terminated under the impulse of some strong energetic feeling, similar in its nature to an instinct. I should not wish to die like Attila, in a moment of gross sensual enjoyment; but the death of Epaminondas or Nelson, in the arms of victory, their whole attention absorbed in the love of glory, and of their country, I think really enviable.

"*Poietes.*—I consider the death of the martyr or the saint as far more enviable; for, in this case, what may be considered as a divine instinct of our nature, is called into exertion, and pain is subdued, or destroyed, by a secure faith in the power and mercy of the Divinity. In such cases, man rises above mortality, and shows his true intellectual superiority. By intellectual superiority, I mean that of his spiritual nature, for I do not consider the results of reason as capable of being compared with those of faith. Reason is often a dead weight in life, destroying feeling, and substituting, for principle, calculation and caution; and, in the hour of death, it often produces fear or despondency, and is rather a bitter draught than nectar or ambrosia in the last meal of life.

" *Halieus.*—I agree with Poietes. The higher and more intense the feeling under which death takes place, the happier it may be esteemed; and I think even Physicus will be of our opinion, when I recollect the conclusion of a conversation in Scotland. The immortal being never can quit life with so much pleasure as with the feeling of immortality secure, and the vision of celestial glory filling the mind, affected by no other passion than the pure and intense love of God."

We are not to suppose that, however soothing and consolatory such feelings and hopes may have been, they weaned him from the world, or diminished his natural love of life; on the contrary, no one would have more gratefully received the services of a Medea, as the following passage will sufficiently testify. "Ah! could I recover any thing like that freshness of mind which I possessed at twenty-five, and which, like the dew of the dawning morning, covered all objects and nourished all things that grew, and in which they were more beautiful even than in midday sunshine,—what would I not give! All that I have gained in an active and not unprofitable life. How well I remember that delightful season, when, full of power, I sought for power in others; and power was sympathy, and sympathy power;—when the dead and the unknown, the great of other ages and of distant places were made, by the force of the imagination, my companions and friends;—when every voice seemed one of praise and love;—when every flower had the bloom and odour of the rose; and every spray or plant seemed either the poet's laurel, or the civic oak—which appeared to offer themselves as wreaths to adorn my throbbing brow. But, alas! this cannot be———"

After the example of the great Patriarch of Anglers, the author of Salmonia commences, through the assistance of the principal interlocutor of the dialogue, Halieus, to enumerate the delights of his art, and to vindicate it from the charge of cruelty.

" *Halieus.*—The search after food is an instinct belonging to our nature; and from the savage in his rudest and most primitive state, who destroys a piece of game, or a fish, with a club or spear, to man in the most cultivated state of society, who employs artifice, machinery, and the resources of various other animals, to secure his object, the origin of the pleasure is similar, and its object the same: but that kind of it requiring most art may be said to characterize man in his highest or intellectual state; and the fisher for salmon and trout with the fly employs not only machinery to assist his physical powers, but applies sagacity to conquer difficulties; and the pleasure derived from ingenious resources and devices, as well as from active pursuit, belongs to this amusement. Then, as to its philosophical tendency, it is a pursuit of moral discipline, requiring patience, forbearance, and command of temper. As connected with natural science, it may be vaunted as demanding a knowledge of the habits of a considerable tribe of created beings,—fishes, and the animals that they prey upon, and an acquaintance with the signs and tokens of the weather, and its changes, the nature of waters, and of the atmosphere. As to its poetical relations, it carries us into the most wild and beautiful scenery of nature; amongst the mountain lakes, and the clear and lovely streams that gush from the higher ranges of elevated hills, or that make their way through the cavities of calcareous strata. How delightful in the early spring, after the dull and tedious time of winter, when the frosts disappear and the sunshine warms the earth and waters, to wander forth by some clear stream, to see the leaf bursting from the purple bud, to scent the odours of the bank perfumed by the violet, and enamelled, as it were, with the primrose and the daisy; to wander upon the fresh turf below the shade of trees, whose bright blossoms are filled with the music of the bee; and on the surface of the waters to view the gaudy flies sparkling like animated gems in the sunbeams, whilst the bright and beautiful trout is watching them from below; to hear the twittering of the water birds, who, alarmed at your approach, rapidly hide themselves beneath the flowers and leaves of the water lily; and, as the season advances, to find all these objects changed for others of the same kind, but better and brighter, till the swallow and the trout contend, as it were, for the gaudy May fly, and till, in pursuing your amusement in the calm and balmy evening, you are serenaded by the songs of the cheerful thrush and melodious nightingale, performing the offices of paternal love, in thickets ornamented with the rose and woodbine."

On vindicating the pursuit from the charge of cruelty, he has advanced an argument that has not been commonly adduced upon this occasion. We have indeed all heard, that the operation of skinning is a matter of indifference to eels when they are used to it; but we are now told fish are so little annoyed by the hook, that though a trout has been hooked and played with for some minutes, he will often, after his escape with the artificial fly in his mouth, take the natural fly, and feed as if nothing had happened; having apparently learnt only from the experiment, that the artificial fly is not proper food. "I have caught pikes with four or five hooks in their mouths, and tackle which they had broken only a few minutes before; and the hooks seemed to have had no other effect than that of serving as a sort of *sauce piquante,* urging them to seize another morsel of the same kind."

Our author, however, takes a more special defence, by observing that, unlike old Isaac, he employs an artificial fly, instead of a living bait. Our notions about the cruelty of field sports is extremely capricious. Until the time of the Reformation, the canon law prohibited the use of the sanguinary recreations of hunting, hawking, and fowling, while the clergy, on account of their leisure, were allowed to exercise the harmless and humane art of angling. In later days, the indignation against this art has been excited by the supposed sufferings of the worm or bait, rather than by those of the fish; and thus far the author of Salmonia assumed a strong posture of defence; but he did not avail himself of all the advantages it commanded. He might have pleaded, that every fish he caught by his artificial fly was destined to prey upon an insect, and that by substituting a piece of silk for the latter, he would for every fish he might destroy, save from destruction many of those fairy beings that animate the air and sparkle in the sunbeam;—but it is, after all, folly to argue upon the subject of cruelty in our field sports. That animals should live by preying upon each other is the very basis of the scheme of creation; and in these days it is not necessary to expose the absurdities of the system of Samos and Indostan. Dr. Franklin, at one period of his life, entertained a sentimental abhorrence at eating any thing that had possessed life; and the reader may, perhaps, not object to be reminded of the manner in which he was cured of his prejudice. "I considered," says he, "the capture of every fish as a sort of murder, committed without provocation, since these animals had neither done, nor were capable of doing, the smallest injury to any one that should justify the measure. This mode of reasoning I conceived to be unanswerable. Meanwhile, I had formerly been extremely fond of fish; and when one of the cod was taken out of the frying-pan, I thought its flavour delicious. I hesitated some time between principle and inclination, till at last recollecting that, when the cod had been opened, some small fish were found in its belly, I said to myself, 'If you eat each other, I see no reason why we may not eat you,'—(His "wish was father to that thought")—I accordingly dined on the cod with no small degree of pleasure, and have since continued to eat like the rest of mankind."

Halieus is made to admit the danger of analysing too closely the moral character of any of our field sports; and yet, in the concluding chapter, he very unfairly and inconsistently attempts to ridicule the pursuit of a fox-hunter, "risking his neck to see the hounds destroy an animal which he preserves to be destroyed, and which is good for nothing." He who pursues a pleasure because it is rational, reasons because he cannot feel. "When the heart," says Sterne, "flies out before the understanding, it saves the judgment a world of pains."

Having, as the author thinks satisfactorily, settled the preliminary questions, Halieus, succeeds in persuading Physicus to join him in fishing excursions; just as *Piscator* is represented by old Isaac, as having enlisted *Venator* into the brotherhood of the angle.

The dialogue now proceeds with great animation, during which the art and mystery of Piscatory tactics are unfolded with great skill; for the details of which the reader must be referred to the work itself. If, however, he be not already an angler, it may save him a world of pains to be informed, that to learn to fish by the book is little less absurd than "to make hay by the fair days in the almanack."

The manner in which he treats the various subjects of natural history necessarily connected with the pursuit is both amusing and instructive; and the whole work is studded and gemmed, as it were, with the most poetical descriptions.

In speaking of the swallow, Poietes exclaims—"I delight in this living landscape! The swallow is one of my favourite birds, and a rival of the nightingale; for he cheers my sense of seeing as much as the other does my sense of hearing. He is the glad prophet of the year, the harbinger of the best season: he lives a life of enjoyment amongst the loveliest forms of nature: winter is unknown to him; and he leaves the green meadows of England in autumn, for the myrtle and orange groves of Italy, and for the palms of Africa: he has always objects of pursuit, and his success is secure. Even the beings selected for his prey are poetical, beautiful, and transient. The ephemeræ are saved by his means from a slow and lingering death in the evening, and killed in a moment, when they have known nothing of life but pleasure. He is the constant destroyer of insects—the friend of man; and, with the stork and the ibis, may be regarded as a sacred bird. His instinct, which gives him his appointed seasons, and teaches him always when and where to move, may be regarded as flowing from a divine source;

and he belongs to the oracles of Nature, which speak the awful and intelligible language of a present Deity."

Poietes considers a full and clear river as the most poetical object in Nature.—"I will not fail to obey your summons. Pliny has, as well as I recollect, compared a river to human life. I have never read the passage in his works; but I have been a hundred times struck with the analogy, particularly amidst mountain scenery. The river, small and clear in its origin, gushes forth from rocks, falls into deep glens, and wantons and meanders through a wild and picturesque country, nourishing only the uncultivated tree or flower by its dew or spray. In this, its state of infancy and youth, it may be compared to the human mind, in which fancy and strength of imagination are predominant—it is more beautiful than useful. When the different rills or torrents join, and descend into the plain, it becomes slow and stately in its motions; it is applied to move machinery, to irrigate meadows, and to bear upon its bosom the stately barge;—in this mature state it is deep, strong, and useful. As it flows on towards the sea, it loses its force and its motion, and at last, as it were, becomes lost, and mingled with the mighty abyss of waters."

Halieus adds—"One might pursue the metaphor still farther, and say, that in its origin—its thundering and foam, when it carries down clay from the bank, and becomes impure, it resembles the youthful mind, affected by dangerous passions. And the influence of a lake, in calming and clearing the turbid water, may be compared to the effect of reason in more mature life, when the tranquil, deep, cool, and unimpassioned mind is freed from its fever, its troubles, bubbles, noise, and foam. And, above all, the sources of a river —which may be considered as belonging to the atmosphere—and its termination in the ocean, may be regarded as imaging the divine origin of the human mind, and its being ultimately returned to, and lost in, the infinite and eternal intelligence from which it originally sprang."

Halieus offers some curious observations with respect to the recollection of fish being associated with surrounding objects.

"I have known a fish that I have pricked retain his station in the river, and refuse the artificial fly, day after day, for weeks together; but his memory may have been kept awake by this practice, and the recollection seems local, and associated with surrounding objects; and if a pricked trout is chased into another pool, he will, I believe, soon again take the artificial fly. Or, if the objects around him are changed, as in autumn, by the decay of weeds, or by their being cut, the same thing happens; and a flood or a rough wind, I believe, assists the fly-fisher, not merely by obscuring the vision of the fish, but, in a river much fished, by changing the appearance of their haunts: large trouts almost always occupy particular stations, under, or close to, a large stone or tree; and probably, most of their recollected sensations are connected with this dwelling.

"*Physicus.*—I think I understand you, that the memory of the danger and pain does not last long, unless there is a permanent sensation with which it can remain associated,—such as the station of the trout; and that the recollection of the mere form of the artificial fly, without this association, is evanescent.

"*Ornither.*—You are diving into metaphysics; yet, I think, in fowling, I have observed that the memory of birds is local. A woodcock that has been much shot at and scared in a particular wood, runs to the side where he has usually escaped, the moment he hears the dogs; but if driven into a new wood, he seems to lose his acquired habits of caution, and becomes stupid."

In alluding to the migrations of fishes, *Physicus* observes, "that he has always considered that the two great sources of change of place of animals, was the providing of food for themselves, and resting-places and food for their young. The great supposed migrations of herrings from the poles to the temperate zone appear to be only the approach of successive shoals from deep to shallow water, for the purpose of spawning. The migrations of salmon and trout are evidently for the purpose of depositing their ova, or of finding food after they have spawned."

In explaining the circumstances which render a migration into shallow water necessary for the developement of the ova, Davy evidently bears in mind the result of his very first experiment.*

"Carp, perch, and pike, deposit their ova in still water, in spring and summer, *when it is supplied with air by the growth of vegetables; and it is to the leaves of plants, which afford a continual supply of oxygen to the water, that the impregnated eggs usually adhere.*"—Again: "Fish in spawning time always approach great shallows, or shores covered with weeds, *which, in the process of their growth, under the influence of the sunshine, constantly supply pure air to the water in contact with them.*"

The following passage will afford a good specimen of the familiar dialogue, while it will convey to the reader some curious facts connected with the influence of sunshine.

* Page 30.

"*Halieus.*—Well, gentlemen, what sport?

"*Poietes.*—The fish are rising every where; but though we have been throwing over them with all our skill for a quarter of an hour, yet not a single one will take; and I am afraid we shall return to breakfast without our prey.

"*Halieus.*—I will try; but I shall go to the other side, where I see a very large fish rising—There!—I have him at the very first throw—Land this fish, and put him into the well. Now, I have another; and I have no doubt I could take half-a-dozen in this very place, where you have been so long in fishing without success.

"*Physicus.*—You must have a different fly; or, have you some unguent or charm to tempt the fish?

"*Halieus.*—No such thing. If any of you will give me your rod and fly, I will answer for it I shall have the same success. I take your rod, Physicus—and lo! I have a fish!

"*Physicus.*—What can be the reason of this? It is perfectly inexplicable to me. Yet Poietes seems to throw as light as you do, and as well as he did yesterday.

"*Halieus.*—I am surprised that you, who are a philosopher, cannot discover the reason of this—Think a little.

"*All.*—We cannot.

"*Halieus.*—As you are my scholars, I believe I must teach you. The sun is bright, and you have been, naturally enough, fishing with your backs to the sun, which, not being very high, has thrown the shadows of your rods and yourselves upon the water, and you have alarmed the fish, wherever you have thrown a fly. You see, I have fished with my face towards the sun, and though inconvenienced by the light, have given no alarm. Follow my example, and you will soon have sport, as there is a breeze playing on the water.

"*Physicus.*—Your sagacity puts me in mind of an anecdote which I remember to have heard respecting the late eloquent statesman, Charles James Fox; who, walking up Bond Street from one of the club-houses with an illustrious personage, laid him a wager, that he would see more cats than the Prince in his walk, and that he might take which side of the way he liked. When they got to the top, it was found, that Mr. Fox had seen thirteen cats, and the Prince not one. The Royal personage asked for an explanation of this apparent miracle, and Mr. Fox said, 'Your Royal Highness took, of course, the shady side of the way, as most agreeable; I knew that the sunny side would be left to me,—and cats always prefer the sunshine.

"*Halieus.*—There! Poietes, by following my advice, you have immediately hooked a fish; and while you are catching a brace, I will tell you an anecdote, which as much relates to fly-fishing as that of Physicus, and affords an elucidation of a particular effect of light.

"A manufacturer of carmine, who was aware of the superiority of the French colour, went to Lyons for the purpose of improving his process, and bargained with the most celebrated manufacturer in that capital for the acquisition of his secret, for which he was to pay a thousand pounds. He was shown all the processes, and saw a beautiful colour produced, yet he found not the least difference in the French mode of fabrication and that which he had constantly adopted. He appealed to the manufacturer, and insisted that he must have concealed something. The manufacturer assured him that he had not, and invited him to see the process a second time. He minutely examined the water and the materials, which were the same as his own, and, very much surprised, said, 'I have lost my labour and my money, for the air of England does not permit us to make good carmine.'—'Stay,' says the Frenchman, 'do not deceive yourself; what kind of weather is it now?'—'A bright, sunny day,' said the Englishman. 'And such are the days,' said the Frenchman, 'on which I make my colour. Were I to attempt to manufacture it on a dark or cloudy day, my result would be the same as yours. Let me advise you, my friend, always to make carmine on bright and sunny days.' 'I will,' says the Englishman, 'but I fear I shall make very little in London.'

"*Poietes.*—Your anecdote is as much to the purpose as Physicus's; yet I am much obliged to you for the hint respecting the effect of shadow, for I have several times, in May and June, had to complain of too clear a sky, and wished, with Cotton, for

'A day with not too bright a beam;
A warm, but not a scorching sun.'"

A very amusing and philosophical conversation on those natural phenomena, which have been vulgarly viewed as prophetic of dry or wet weather, may be well adduced as illustrative of that genius which, by the aid of a light of its own, imparts to the most trite objects all the charms of novelty.

"*Poietes.*—I hope we shall have another good day to-morrow, for the clouds are red in the west.

" *Physicus.*—I have no doubt of it, for the red has a tint of purple.

" *Halieus.*—Do you know why this tint portends fine weather?

" *Physicus.*—The air when dry, I believe, refracts more red, or heat-making rays; and as dry air is not perfectly transparent, they are again reflected in the horizon. I have generally observed a coppery or yellow sunset to foretell rain; but, as an indication of wet weather approaching, nothing is more certain than a halo round the moon, which is produced by the precipitated water; and the larger the circle, the nearer the clouds, and consequently the more ready to fall.

" *Halieus.*—I have often observed, that the old proverb is correct—

> ' A rainbow in the morning is the shepherd's warning;
> A rainbow at night is the shepherd's delight.'

—Can you explain this omen?

" *Physicus.*—A rainbow can only occur when the clouds containing or depositing the rain are opposite to the sun; and in the evening the rainbow is in the east, and in the morning in the west; and as our heavy rains in this climate are usually brought by the westerly wind, a rainbow in the west indicates that the bad weather is on the road, by the wind, to us; whereas the rainbow in the east proves, that the rain in these clouds is passing from us.

" *Poietes.*—I have often observed, that when the swallows fly high, fine weather is to be expected or continued; but when they fly low and close to the ground, rain is almost surely approaching. Can you account for this?

" *Halieus.*—Swallows follow the flies and gnats, and flies and gnats usually delight in warm strata of air; and as warm air is lighter, and usually moister than cold air, when the warm strata of air are high, there is less chance of moisture being thrown down from them by the mixture with cold air; but when the warm and moist air is close to the surface, it is almost certain, that as the cold air flows down into it, a deposition of water will take place.

" *Poietes.*—I have often seen sea-gulls assemble on the land, and have almost always observed, that very stormy and rainy weather was approaching. I conclude that these animals, sensible of a current of air approaching from the ocean, retire to the land to shelter themselves from the storm.

" *Ornither.*—No such thing. The storm is their element; and the little petrel enjoys the heaviest gale; because, living on the smaller sea insects, he is sure to find his food in the spray of a heavy wave. And you may see him flitting above the edge of the highest surge. I believe that the reason of the migration of sea-gulls and other sea birds to the land, is their security of finding food. They may be observed, at this time, feeding greedily on the earth worms and larvæ driven out of the ground by severe floods; and the fish on which they prey in fine weather in the sea leave the surface when storms prevail, and go deeper. The search after food, as we agreed on a former occasion, is the principal cause why animals change their places. The different tribes of the wading birds always migrate when rain is about to take place; and I remember once in Italy having been long waiting, in the end of March, for the arrival of the double snipe in the Campagna of Rome: a great flight appeared on the 3rd of April, and the day after heavy rain set in, which greatly interfered with my sport. The vulture, upon the same principle, follows armies; and I have no doubt, that the augury of the ancients was a good deal founded upon the observation of the instincts of birds. There are many superstitions of the vulgar owing to the same source. For anglers, in spring, it is always unlucky to see *single* magpies; but *two* may be always regarded as a favourable omen; and the reason is, that in cold and stormy weather one magpie alone leaves the nest in search of food, the other remaining sitting upon the eggs or the young ones; but when two go out together, the weather is warm and mild, and thus favourable for fishing.

" *Poietes.*—The singular connexions of cause and effect, to which you have just referred, make superstition less to be wondered at, particularly amongst the vulgar; and when two facts, naturally unconnected, have been accidentally coincident, it is not singular that this coincidence should have been observed and registered, and that omens of the most absurd kind should be trusted in. In the West of England, half a century ago, a particular hollow noise on the sea-coast was referred to a spirit or goblin, called Bucca, and was supposed to foretell a shipwreck; the philosopher knows, that sound travels much faster than currents in the air—and the sound always foretold the approach of a very heavy storm, which seldom takes place on that wild and rocky coast, surrounded as it is by the Atlantic, without a shipwreck on some part of its extensive shores.*

" *Physicus.*—All the instances of omens you have mentioned are founded on

* Davy might also have adduced an equally striking superstition, in illustration of his subject, from the Cornish mines. The miners not unfrequently hear the echo of their own pickaxes, which they attribute to little fairies at work, and consider it as a happy omen. They say upon such occasions, that there will be good luck, as the Piskeys are at work. It is well known that the echo depends upon some cavity in the vicinity of the workmen,—and a cavity, or vogue, is always an indication of subterranean wealth.

reason; but how can you explain such absurdities as Friday being an unlucky day, the terror of spilling salt, or meeting an old woman? I knew a man of very high dignity, who was exceedingly moved by these omens, and who never went out shooting without a bittern's claw fastened to his button-hole by a riband—which he thought ensured him good luck.

"*Poietes.*—These, as well as the omens of death-watches, dreams, &c. are for the most part founded upon some accidental coincidences; but spilling of salt, on an uncommon occasion, may, as I have known it, arise from a disposition to apoplexy, shown by an incipient numbness in the hand, and may be a fatal symptom; and persons dispirited by bad omens sometimes prepare the way for evil fortune; for confidence in success is a great means of insuring it. The dream of Brutus, before the field of Philippi, probably produced a species of irresolution and despondency, which was the principal cause of his losing the battle; and I have heard, that the illustrious sportsman, to whom you referred just now, was always observed to shoot ill, because he shot carelessly, after one of his dispiriting omens.

"*Halieus.*—I have in life met with a few things, which I found it impossible to explain, either by chance, coincidences, or by natural connexions; and I have known minds of a very superior class affected by them,—persons in the habit of reasoning deeply and profoundly.

"*Physicus.*—In my opinion, profound minds are the most likely to think lightly of the resources of human reason; it is the pert, superficial thinker who is generally strongest in every kind of unbelief. The deep philosopher sees chains of causes and effects so wonderfully and strangely linked together, that he is usually the last person to decide upon the impossibility of any two series of events being independent of each other; and in science, so many natural miracles, as it were, have been brought to light,—such as the fall of stones from meteors in the atmosphere, the disarming a thunder cloud by a metallic point, the production of fire from ice by a metal white as silver, and referring certain laws of motion of the sea to the moon,—that the physical enquirer is seldom disposed to assert, confidently, on any abstruse subjects belonging to the order of natural things, and still less so on those relating to the more mysterious relations of moral events and intellectual natures."

Old Izaac Walton has amused us with a variety of absurd fables and superstitions: the author of Salmonia, on the other hand, touches, as with the spear of Ithuriel, the monsters and prodigies of the older writers, and they at once assume the forms of well-ascertained animals, or vegetables. The *sea* *snake* seen by American and Norwegian captains, appears as a company of porpoises, which in their gambols, by rising and sinking in lines, would give somewhat the appearance of the coils of a snake. The *Kraken*, or island fish, is reduced into an assemblage of *urticæ marinæ*, or sea blubbers. The *Mermaid*, into the long-haired seal;* and lastly, the celebrated Caithness Mermaid assumes the unpoetical form of a stout young traveller;—but this story is far too amusing to be dismissed with a passing notice.

"A worthy baronet, remarkable for his benevolent views and active spirit, has propagated a story of this kind, and he seems to claim for his native country the honour of possessing this extraordinary animal; but the mermaid of Caithness was certainly a *gentleman*, who happened to be travelling on that wild shore, and who was seen bathing by some young ladies at so great a distance, that not only *genus* but gender was mistaken. I am acquainted with him, and have had the story from his own mouth. He is a young man, fond of geological pursuits, and one day in the middle of August, having fatigued and heated himself by climbing a rock to examine a particular appearance of granite, he gave his clothes to his Highland guide, who was taking care of his pony, and descended to the sea. The sun was just setting, and he amused himself for some time by swimming from rock to rock, and having unclipped hair and no cap, he sometimes threw aside his locks, and wrung the water from them on the rocks. He happened the year after to be at Harrowgate, and was sitting at table with two young ladies from Caithness, who were relating to a wondering audience the story of the mermaid they had seen, which had already been published in the newspapers: they described her, as she usually is described by Poets, as a beautiful animal with remarkably fair skin, and long green hair. The young gentleman took the liberty, as most of the rest of the company did, to put a few questions to the elder of the two ladies,—such as, on what day and precisely where this singular phenomenon had appeared. She had noted down not merely the day, but the hour and minute, and produced a map of the place. Our bather referred to his journal, and showed that a human animal was swimming in the very spot at that very time, who had some of the characters ascribed to the mermaid, but who laid no claim to others, particularly the green hair, and fish's tail;

* A pretended Mermaid was exhibited some time since in London, said to have been caught in the Chinese seas. It was soon discovered to have been manufactured by joining together the head and bust of two different apes to the lower part of a kipper salmon which had the fleshy fin, and all the distinct characters of the *Salmo Salar*.

but being rather sallow in the face, was glad to have such testimony to the colour of his body beneath his garments."

With this story, I must conclude my review of Salmonia,—a work of considerable scientific and popular interest, and which cannot fail to become the favourite companion of the philosophical angler. The only production with which it can be at all compared is that of the "Complete Angler, by Izaac Walton." I agree with the critic who regards the two authors as pilgrims bound for the same shrine, resembling each other in their general habit—the scalloped hat, the dalmatique, and the knobbed and spiked staff—which equalize all who assume the character; yet, though alike in purpose, dress, and demeanour, the observant eye can doubtless discern an essential difference betwixt those devotees. The burgess does not make his approach to the shrine with the stately pace of a knight or a noble; the simple and uninformed rustic has not the contemplative step of the philosopher, or the quick glance of the poet. The palm of originality and of exquisite simplicity, which cannot perhaps be imitated with entire success, must remain with the common father of anglers—the patriarch Izaac; but it would be absurd to compare his work with the one written by the most distinguished philosopher of the nineteenth century, whose genius, like a sunbeam, illumined every recess which it penetrated, imparting to scarcely visible objects, definite forms and various colours.

If the advanced age of Walton was pleaded by himself as a sufficient reason for procuring "*a writ of ease*," the friends of Davy may surely claim at the hands of the critic an indulgent reception for a congenial work written in the hour of bodily lassitude and sickness. This benevolent feeling, however, did not penetrate every heart. A passage, which I shall presently quote, appears to have given great offence to the President of the Mechanics' Institute, and to have been considered by him as the indication of a covert hostility to the spread of knowledge. The earth had scarcely closed upon the remains of the philosopher, when, in his anniversary speech,* the Autocrat of all the Mechanics, availing himself of this pretext, assailed his character with the charge of "conceit, pride, and arrogance."

The following is the passage in Salmonia, which provoked this angry and unjust philippic.

* See a Report of the President's speech, at the sixth anniversary of the Mechanics' Institute, as reported in all the journals of the day, December 5, 1829.

"I am sorry to say, I think the system carried too far in England. God forbid, that any useful light should be extinguished! let the persons who wish for education receive it; but it appears to me that, in the great cities in Eng land, it is, as it were, forced upon the population; and that sciences, which the lower classes can only very superficially acquire, are presented to them; in consequence of which they often become idle and conceited, and above their usual laborious occupations. The unripe fruit of the tree of knowledge is, I believe, always bitter or sour; and scepticism and discontentment—sicknesses of the mind—are often the result of devouring it."

Methinks I hear the reader exclaim—"How little could Davy imagine that his prophetic words would have been so soon fulfilled!"—But I would seriously recommend to the President of the Mechanics' Institute, an anecdote which, if properly applied, cannot fail to be instructive.—When Diogenes, trampling with his dirty feet on the embroidered couch of Plato, cried out—"*Thus do I trample on the pride of Plato!*" the philosopher shook his head, and replied—"*Truly, but with more pride thou dost it, good Diogenes.*"

CHAPTER XV.

Sir H. Davy's Paper on the Phenomena of Volcanoes.—His experiments on Vesuvius.—Theory of Volcanic action.—His reception abroad.—Anecdotes.—His last Letter to Mr. Poole from Rome. —His Paper on the electricity of the Torpedo.—Consolations in Travel, or the Last Days of a Philosopher.—Analysis of the work.—Reflections suggested by its style and composition.—Davy and Wollaston compared.—His last illness.—Arrival at Geneva.—His DEATH.

A SHORT time before Sir Humphry Davy quitted England, to which he was destined never to return, he communicated to the Royal Society a paper "On the Phenomena of Volcanoes;" which was read on the 20th of March 1828, and published in the Transactions of that year.

The object of this memoir was to collect and record the various observations and experiments which he had made on Vesuvius, during his several visits to that volcano. The appearances which it presented in 1814 and 1815 have been already noticed; it was in December 1819, and during the two succeeding months, that the mountain offered a favourable opportunity for making those experiments which form the principal subject of the present communication.

It was a point of great importance to determine whether any combustion was going on at the moment the lava issued from the mountain; for this fact being once discovered, and the nature of the combustible matter ascertained, we should gain an immense step towards a just theory of the sources of volcanic action. For this purpose, he carefully examined both the lava and the elastic fluids with which it was accompanied. He was unable, however, to detect any thing like deflagration with nitre, which must have taken place had the smallest quantity of carbonaceous matter been present; nor could he, by exposing the ignited mass to portions of atmospheric air, discover that any appreciable quantity of oxygen had been absorbed. On immersing fused lava in water, no decomposition of that fluid followed, so that there could not have existed any quantity of the metallic bases of the alkalies or earths. Common salt, chloride of iron, the sulphates and muriates of potash, and soda, generally constituted the mass of solid products; while steam, muriatic acid fumes, and occasionally sulphurous acid vapours, formed the principal elastic matters disengaged.

He informs us it was on the 26th of January 1820, that he had the honour to accompany his Royal Highness the Prince of Denmark in an excursion to the mountain, on which occasion his friend, Cavalier Monticelli, was also present. At this time, the lava was seen nearly white hot through a chasm near the place where it flowed from the mountain; and yet, although he threw nitre upon it in large quantities through this chasm, there was no more increase of ignition than when the experiment was made on lava exposed to the free air. He observed that the appearance of the sublimations was very different from that which they had presented on former occasions; those near the aperture were coloured green and blue by salt of copper; but there was, as usual, a great quantity of muriate of iron. On the 5th, the sublimate of the lava was pure chloride of sodium; in the sublimate of January 6th, there were both sulphate of soda and indications of sulphate of potash; but in those which he collected during this last visit, the sulphate of soda was in much larger quantities, and there was much more of a salt of potash.

For nearly three months the craters, of which there were two, were in activity. The larger one threw up showers of ignited ashes and stones to a height apparently of from two hundred to two hundred and fifty feet; and from the smaller crater steam arose with great violence. Whenever the crater could be approached, it was found incrusted with saline matter: and the walk to the edge of the small crater, on the 6th of January, was through a mass of loose saline matter, principally common salt coloured by muriate of iron, in which the foot sunk to some depth. It was easy, even at a great distance, to distinguish between the steam disengaged by one of the craters, and the earthy matter thrown up by the other. The steam appeared white in the day, and formed perfectly white clouds, which reflected the morning and evening light of the purest tints of red and orange. The earthy matter always appeared as a black smoke, forming dark clouds, and in the night it was highly luminous at the moment of the explosion.

He concludes this paper on Volcanoes with some observations on the theory of their phenomena. " It appears," says he, " almost demonstrable, that none of the chemical causes anciently assigned for volcanic fires can be true. Amongst these, the combustion of mineral coal is one of the most current; but it seems wholly inadequate to account for the phenomena. However large the stratum of pit-coal, its combustion under the surface could never produce violent and excessive heat; for the production of carbonic acid gas, when there was no free circulation of air, must tend constantly to impede the process: and it is scarcely possible that carbonaceous matter, if such a cause existed, should not be found in the lava, and be disengaged with the saline or aqueous products from the bocca or craters. There are many instances in England of strata of mineral coal which have been long burning; but the results have been merely baked clay and schists, and it has produced no result similar to lava.

"If the idea of Lemery were correct, that the action of sulphur on iron may be a cause of volcanic fires, sulphate of iron ought to be the great product of the volcano; which is known not to be the case; and the heat produced by the action of sulphur on the common metals is quite inadequate to account for the appearances. When it is considered that volcanic fires occur and intermit with all the phenomena that indicate intense chemical action, it seems not unreasonable to refer them to chemical causes. But for phenomena upon such a scale, an immense mass of matter must be in activity, and the products of the volcano ought to give an idea of the nature of the substances primarily active. Now, what are these products? Mixtures of the earths in an oxidated and fused state, and intensely ignited; water and saline substances, such as might be furnished by the sea and air, altered in such a manner as might be expected from the formation of fixed oxidated matter. But it may be said, if the oxidation of the metals of the earths be the causes of the phenomena, some of these substances ought occasionally to be found in the lava, or the combustion ought to be increased at the moment the materials passed into the atmosphere. But the reply to this objection is, that it is evident that the changes which occasion volcanic fires take place in immense subterranean cavities; and that the access of air to the acting substances occurs long before they reach the exterior surface.

"There is no question but that the ground under the solfaterra is hollow; and there is scarcely any reason to doubt of a subterraneous communication between this crater and that of Vesuvius: whenever Vesuvius is in an active state, the solfaterra is comparatively tranquil. I examined the bocca of the solfaterra on the 21st of February 1820, two days before the activity of Vesuvius was at its height: the columns of steam which usually arise in large quantities when Vesuvius is tranquil, were now scarcely visible, and a piece of paper thrown into the aperture did not rise again; so that there was every reason to suppose the existence of a descending current of air. The subterraneous thunder heard at such great distances under Vesuvius is almost a demonstration of the existence of great cavities below filled with aëriform matter: and the same excavations which, in the active state of the volcano, throw out, during so great a length of time, immense volumes of steam, must, there is every reason to believe, in its quiet state, become filled with atmospheric air.*

"To what extent subterraneous cavities may exist, even in common rocks, is shown in the limestone caverns of Carniola, some of which contain many hundred thousand cubical feet of air; and in proportion as the depth of an excavation is greater, so is the air more fit for combustion.

"The same circumstances which would give alloys of the metals of the earths the power of producing volcanic phenomena, namely, their extreme facility of oxidation, must likewise prevent them from ever being found in a pure combustible state in the products of volcanic eruptions; for before they reach the external surface, they must not only be exposed to the air in the subterranean cavities, but be propelled by steam; which must possess, under the circumstances, at least the same facility of oxidating them as air. Assuming the hypothesis of the existence of such alloys of the metals of the earths as may burn into lava in the interior, the whole phenomena may be easily explained from the action of the water of the sea and air on those metals; nor is there any fact, or any of the circumstances which I have mentioned in the preceding part of this paper, which cannot be easily explained according to that hypothesis. For almost all the volcanoes in the old world of considerable magnitude are near, or at no considerable distance from the sea: and if it be assumed that the first eruptions are produced by the action of sea water upon the metals of the earths, and that considerable cavities are left by the oxidated metals thrown out as lava, the results of their action are such as might be anticipated; for, after the first eruptions, the oxidations which produce the subsequent ones may take place in the caverns below the surface; and when the sea is distant, as in the volcanoes of South America,

* "Vesuvius is a mountain admirably fitted, from its form and situation, for experiments on the effect of its attraction on the pendulum: and it would be easy in this way to determine the problem of its cavities. On Etna the problem might be solved on a larger scale."

they may be supplied with water from great subterranean lakes, as Humboldt states that some of them throw up quantities of fish.

"On the hypothesis of a chemical cause for volcanic fires, and reasoning from known facts, there appears to me no other adequate source than the oxidation of the metals which form the bases of the earths and alkalies; but it must not be denied, that considerations derived from thermometrical experiments on the temperature of mines and of sources of hot water, render it probable that the interior of the globe possesses a very high temperature: and the hypothesis of the nucleus of the globe being composed of fluid matter offers a still more simple solution of the phenomena of volcanic fires than that which has been just developed."

It must be admitted that the concluding sentence of this memoir is rather equivocal. He states that the metalloidal theory of volcanoes is most chemical, but that the hypothesis which assumes the high temperature of the interior of the globe is the most simple; but he leaves us in doubt as to his own belief upon the subject. In his last days, however, we shall find that he offers a less reserved opinion upon this question.

With respect to Sir Humphry Davy's last journey to Rome, I have nothing of particular interest to relate. Universally known and respected, a member of almost every scientific society in Europe, there was not a part of the continent in which he felt as a stranger in a foreign land. I might, in addition to the circumstances which have been already mentioned, relate several anecdotes in proof of the widely-extended popularity which his genius and discoveries had secured for him. The following striking incidents deserve particular notice. —Whilst sporting in Austria, he was assaulted by some peasants; and the outrage was no sooner made known to the Emperor than he expressed his sorrow and indignation in the strongest language, and immediately directed that a party of troops should surround the district, and a most rigorous search be made for the culprits. The search was of course successful, and the "Carinthian boors" received merited chastisement.

For the following anecdote I am indebted to Lady Davy. Her Ladyship was travelling alone, on account of ill health, and upon arriving at Basle, she naturally felt a strong desire to visit its far-famed library; it so happened, however, that Sunday was the only day which afforded her this opportunity, and so strictly is the sabbath observed at that place, that she was at once informed that an admission to the library, under any circumstances, was altogether impossible. She nevertheless addressed a note to the librarian, stating to him her name, and the reasons for her unusual request. He immediately returned an answer, and appointed the hour of ten for her visit. Having shown her all that deserved inspection, he concluded his attentions by saying, " Madam, I have held the keys of this library for thirty years, during which period, only three persons have been admitted to see its treasures on the Sunday; two of these were crowned heads, the third the wife of the most celebrated philosopher in Europe."

The following is the last letter which Davy ever wrote to his much valued friend, Mr. Poole.

TO THOMAS POOLE, ESQ.

MY DEAR POOLE, Rome, Feb. 6, 1829.

I HAVE not written to you during my absence from England, because I had no satisfactory account of any marked progress towards health to give you, and the feelings of an invalid are painful enough for himself, and should, I think, never form a part of his correspondence; for they are not diminished by the conviction that they are felt by others. Would I were better! I would then write to you an agreeable letter from this glorious city; but I am here *wearing away* the winter; a ruin amongst ruins! I am anxious to hear from you,—very anxious, so pray write to me with this address, " Sir H. Davy, Inglese, posta restanti, Rovigo, Italia." You know you must pay the postage to the frontier, otherwise the letters, like one a friend sent to me, will go back to you. Pray be so good as to be particular in the direction,—the " Inglese" is necessary. I hope you got a copy of my little trifle " *Salmonia.*" I ordered copies to be sent to you, to Mr. W——, and to Mr. Baker: but as the course of letters in foreign countries is uncertain, I am not sure you received them; if not, you will have lost little; a *second edition* will soon be out, which will be in every respect more worthy of your perusal, being, I think, twice (not saying much for it) as entertaining and philosophical. I will take care by early orders that you have this book. I write and philosophize a good deal, and have nearly finished a work with a higher aim than the little book I speak of above, and which I shall dedicate to you. It contains the essence of my philosophical opinions, and some of my poetical reveries.

It is, like the "Salmonia," an amusement of my sickness; but "*paulo majora canamus.*" I sometimes think of the lines of Waller, and seem to feel their truth:

> "The soul's dark cottage, batter'd and decay'd,
> Lets in new lights through chinks that Time has made."

I have, notwithstanding my infirmities, attended to scientific objects whenever it was in my power, and I have sent the Royal Society a paper which they will publish, on the peculiar electricity of the Torpedo, which I think bears remotely upon the functions of life. I attend a good deal to Natural History, and I think I have recognised in the Mediterranean a *new species of eel,* a sort of link between the conger and the murœna of the ancients. I have no doubt Mr. Baker is right about the distinction between the conger and the common eel. I am very anxious to hear what he thinks about *their generation.* Pray get from him a distinct opinion on this subject. I am at this moment getting the *eels in the markets* here dissected, and have found *ova* in plenty. Pray tell me particularly what Mr. Baker has done; this is a favourite subject with me, and you can give me no news so interesting. My dear friend, I shall never forget your kindness to me. You, with one other person, have given me the little happiness I have enjoyed since my severe visitation.

I fight against sickness and fate, believing I have still duties to perform, and that even my illness is connected in some way with my being made useful to my fellow-creatures. I have this conviction full on my mind, that intellectual beings spring from the same breath of infinite intelligence, and return to it again, but by different courses. Like rivers born amidst the clouds of heaven, and lost in the deep and eternal ocean—some in youth, rapid and short-lived torrents; some in manhood, powerful and copious rivers; and some in age, by a winding and slow course, half lost in their career, and making their exit through many sandy and shallow mouths. I hope to be at Rovigo about the first week in April. I travel slowly and with my own horses. If you will come and join me there, I can give you a place in a comfortable carriage, and can show you the most glorious country in Europe—Illyria and Styria, and take you to the French frontier before the beginning of autumn,—perhaps to England. If you can come, do so at once. I have two servants, and can accommodate you with every thing. I think of taking some baths before I return, in Upper Austria; but I write as if I were a strong man, when I am like a pendulum, as it were, swinging between death and life.

God bless you, my dear Poole. Your grateful and affectionate friend,

H. Davy.

Pray remember me to our friends at Stowey.

His paper on the Electricity of the Torpedo, to which he alludes in the foregoing letter, appears to have been written shortly after he had finished his Salmonia, as it is dated from Lubiana, Illyria, on the 24th of October, and it was read before the Royal Society on the 20th of November 1828, and published in the first part of the Transactions for 1829. It will be remembered, that this subject had long engaged his attention; and he expresses his surprise that the electricity of living animals should not have been an object of greater attention, both on account of its physiological importance, and its general relation to the science of electro-chemistry.

When Volta discovered his wonderful pile, he imagined he had made a perfect resemblance of the organ of the Gymnotus and Torpedo; and Davy observes, that whoever has felt the shocks of the natural and artificial instruments must have been convinced, as far as sensation is concerned, of their strict analogy.

After the discovery of the *chemical* power of the Voltaic instrument, he was naturally desirous of ascertaining whether this property was possessed by the electrical organs of living animals; for which purpose, he instituted various experiments, but he could not discover that such was the fact. Upon mentioning his researches to Signor Volta, with whom he passed some time in the summer of 1815, the Italian philosopher showed him a peculiar form of his instrument, which appeared to fulfil the conditions of the organs of the torpedo; *viz.* a pile, of which the fluid substance was a very imperfect conductor, such as honey or a strong saccharine extract, which required a certain time to become charged, and which did not decompose water, though it communicated weak shocks.

The discovery by Oersted of the effects of Voltaic electricity on the magnetic needle induced Davy to examine whether the electricity of living animals possessed a similar power. Having, after some trouble, procured two lively and recently caught Torpedos, he passed the shocks from the largest of these animals a number of times through the circuit of an extremely delicate magnetic electrometer, but, although every precaution was used, not the slightest deviation of, or effect on, the needle could be perceived.

" These negative results," says he, " may be explained by supposing that the motion of the electricity in the torpedinal organ is in no measurable time, and that a current of some continuance is necessary to produce the deviation of the magnetic needle; and I found that the magnetic electrometer was equally insensible to the weak discharge of a Leyden jar as to that of the torpedinal organ; though whenever there was a continuous current from the smallest surfaces in Voltaic combinations of the weakest power, but in which some chemical action was going on, it was instantly and powerfully affected. Two series of zinc and silver, and paper moistened in salt and water, caused the permanent deviation of the needle several degrees, though the plates of zinc were only one-sixth of an inch in diameter.

" It would be desirable to pursue these enquiries with the electricity of the Gymnotus, which is so much more powerful than that of the Torpedo; but if they are now to be reasoned upon, they seem to show a stronger analogy between common and animal electricity, than between Voltaic and animal electricity; it is however, I think, more probable that animal electricity will be found of a distinctive and peculiar kind.

" Common electricity is excited upon non-conductors, and is readily carried off by conductors and imperfect conductors. Voltaic electricity is excited upon combinations of perfect and imperfect conductors, and is only transmitted by perfect conductors, or imperfect conductors of the best kind.

" Magnetism, if it be a form of electricity, belongs only to perfect conductors; and, in its modifications, to a peculiar class of them.

" The animal electricity resides only in the imperfect conductors forming the organs of living animals, and its object in the economy of nature is to act on living animals.

" Distinctions might be established in pursuing the various modifications or properties of electricity in these different forms; but it is scarcely possible to avoid being struck by another relation of this subject. The torpedinal organ depends for its powers upon the will of the animal. John Hunter has shown how copiously it is furnished with nerves. In examining the columnar structure of the organ of the torpedo, I have never been able to discover arrangements of different conductors similar to those in galvanic combinations, and it seems not improbable that the shock depends upon some property developed by the action of the nerves.

"To attempt to reason upon any phenomena of this kind as dependent upon a specific fluid would be wholly vain. Little as we know of the nature of electrical action, we are still more ignorant of the nature of the functions of the nerves. There seems, however, a gleam of light worth pursuing in the peculiarities of animal electricity,—its connection with so large a nervous system, its dependence upon the will of the animal, and the instantaneous nature of its transfer, which may lead, when pursued by adequate enquirers, to results important for physiology."

He concludes this paper by expressing his fear that the weak state of his health will prevent him from following the subject with the attention it seems to deserve; and he therefore communicates these imperfect trials to the Royal Society, in the hope that they may lead to more extensive and profound researches.

We come now to the consideration of the last production of his genius—"Consolations in Travel, or the Last Days of a Philosopher:" A work which, he informs us in the preface, was composed immediately after Salmonia, under the same unfavourable and painful circumstances, and at a period when his constitution suffered from new attacks. From this exercise of the mind, he tells us, that he derived some pleasure and some consolation, when most other sources of consolation and pleasure were closed to him; and he ventures to hope that those hours of sickness may be not altogether unprofitable to persons in perfect health. His brother, Dr. Davy, who edited the work after the decease of Sir Humphry, informs us that it was concluded at the very moment of the invasion of the author's last illness, and that, had his life been prolonged, it is probable some additions and some changes would have been made.

"The characters of the persons of the dialogue," continues the Editor, "were intended to be ideal, at least in great part;—such they should be considered by the reader; and it is to be hoped, that the incidents introduced, as well as the persons, will be viewed only as subordinate and subservient to the sentiments and the doctrines. The dedication, it may be specially noticed, is the Author's own, and in the very words dictated by himself at a time when he had lost the power of writing, except with extreme difficulty, owing to the paralytic attack, although he retained in a very remarkable manner all his mental faculties unimpaired and unclouded." The words of the Dedication are "To Thomas Poole, Esq. of Nether Stowey; in remembrance of thirty years of continued and faithful friendship."

This is a most extraordinary and interesting work: extraordinary, not only from the wild strength of its fancy, and the extravagance of its conceptions, but from the bright light of scientific truth which is constantly shining through its metaphorical tissue, and irradiating its most shadowy imaginings. It may be compared to the tree of the lower regions in the Æneid, to every leaf of which was attached a dream; and yet, however wildly his fancy may dream, his philosophy never sleeps; and in his exit from the land of phantoms, the author can in no instance be accused of having mistaken the gate of ivory for that of horn. To the biographer, the work is of the highest interest and value, by confirming, in a remarkable manner, the opinion so frequently expressed in the course of these memoirs, with respect to the diversified talents of Sir Humphry Davy; and above all, by elucidating that rare combination of imagination with judgment, which imparted to his genius its more striking peculiarities.

The work consists of six Dialogues:—1. THE VISION; 2. DISCUSSIONS CONNECTED WITH THE VISION IN THE COLOSÆUM; 3. THE UNKNOWN; 4. THE PROTEUS, OR IMMORTALITY; 5. THE CHEMICAL PHILOSOPHER; and 6. POLA, OR TIME.

The interlocutors of the first dialogue are two intellectual Englishmen, one of whom the author calls *Ambrosio;* a man of highly cultivated taste, great classical erudition, and minute historical knowledge: a Catholic in religion, but so liberal in his sentiments, that in another age he might have been secretary to Ganganelli. The other friend, whom he calls *Onuphrio*, was a man of a very different character: belonging to the English aristocracy, he had some of the prejudices usually attached to birth and rank; but his manners were gentle, his temper good, and his disposition amiable. Having been partly educated at a northern university in Britain, he had adopted views in religion which went even beyond toleration, and which might be regarded as entering the verge of scepticism. For a patrician, he was very liberal in his political views. His imagination was poetical and discursive, his taste good, and his tact extremely fine,—so exquisite, indeed, that it sometimes approached to morbid sensibility, and disgusted him with slight defects, and made him keenly sensible of small perfections to which common minds have been indifferent.

The author, with these his two friends, makes an excursion to the Colosæum, and the conversation, which a view of those magnificent ruins produced, together with the account of a dream, or vision, which occurred to him while left alone amidst these mouldering monuments, forms the subject matter of the first dialogue. It is impossible for any person of the least imagination to contemplate this decay of former magnificence without strong emotion; but the direction and tone of such feeling will be necessarily modified by the qualities of the mind in which it is excited; and the author has therefore very properly assigned to each of the *dramatis personæ*, such opinions as might best correspond with his character and temperament.

They are all represented as being struck with the transiency of human monuments; but *Ambrosio* views with triumph the sanctifying influence of a few crosses planted around the ruins, in arresting the farther decay of the pile. "Without the influence of Christianity," he exclaims, "these majestic ruins would have been dispersed or levelled to the dust. Plundered of their lead and iron by the barbarians, Goths and Vandals, and robbed even of their stones by Roman princes—the Barberini, they owe what remains of their relics to the sanctifying influence of that faith which has preserved for the world all that was worth preserving, not merely arts and literature, but likewise that which constitutes the progressive nature of intellect, and the institutions which afford to us happiness in this world, and hopes of a blessed immortality in the next." And he continues,—"What a contrast the present application of this building, connected with holy feelings and exalted hopes, is to that of the ancient one, when it was used for exhibiting to the Roman people the destruction of men by wild beasts, or of men more savage than wild beasts by each other, to gratify a horrible appetite for cruelty, founded upon a still more detestable lust, that of universal domination! And who would have supposed, in the time of Titus, that a faith, despised in its insignificant origin, and persecuted from the supposed obscurity of its founder and its principles, should have reared a dome to the memory of one of its humblest teachers, more glorious than was ever framed for Jupiter or Apollo in the ancient world, and have preserved even the ruins of the temples of the Pagan deities, and have burst forth in splendour and majesty, consecrating truth amidst the shrines of error, employing the idols of the Roman superstition for the most holy purposes, and rising a bright and constant light amidst the dark and starless night which followed the destruction of the Roman empire!"

It was not to be expected that *Onuphrio*, whose views are represented as verging upon scepticism, should have tacitly coincided in these opinions of *Ambrosio*. He admits, indeed, that some little of the perfect state in which these ruins exist may have been owing to the causes just described; but these causes, he maintains, have only lately begun to operate, and the mischief was done before Christianity was established at Rome. " Feeling differently on these subjects," says he, " I admire this venerable ruin rather as the record of the destruction of the power of the greatest people that ever existed, than as a proof of the triumph of Christianity; and I am carried forward, in melancholy anticipation, to the period when even the magnificent dome of St. Peter's will be in a similar state to that in which the Colosseum now is, and when its ruins may be preserved by the sanctifying influence of some new and unknown faith; when perhaps the statue of Jupiter, which at present receives the kiss of the devotee, as the image of St. Peter, may be employed for another holy use, as the personification of a future saint or divinity; and when the monuments of the Papal magnificence shall be mixed with the same dust as that which now covers the tombs of the Cæsars.

" Such, I am sorry to say, is the general history of all the works and institutions belonging to humanity. They rise, flourish, and then decay and fall; and the period of their decline is generally proportional to that of their elevation. In ancient Thebes or Memphis, the peculiar genius of the people has left us monuments from which we can judge of their arts, though we cannot understand the nature of their superstitions. Of Babylon and of Troy, the remains are almost extinct; and what we know of those famous cities is almost entirely derived from literary records. Ancient Greece and Rome we view in the few remains of their monuments; and the time will arrive when modern Rome shall be what ancient Rome now is; and ancient Rome and Athens will be what Tyre or Carthage now are, known only by coloured dust in the desert, or coloured sand, containing the fragments of bricks, or glass, washed up by the wave of a stormy sea."

For this desponding view of passing events, *Onuphrio* finds consolation in the evidences of revealed religion. In the origin, progress, elevation, decline, and fall of the empires of antiquity, he sees proofs that they were intended for a definite end in the scheme of human redemption; and he finds prophecies which have been amply verified. He regards the foundation or the ruin of a kingdom, which appears in civil history so great an event, as comparatively of small moment in the history of man and in his religious institutions. He considers the establishment of the worship of one God amongst a despised and contemned people, as the most important circumstance in the history of the early world. He regards the Christian dispensation as naturally arising out of the Jewish, and the doctrines of the Pagan nations all preparatory to the triumph and final establishment of a creed fitted for the most enlightened state of the human mind, and equally adapted to every climate and every people."

We cannot but regard these passages with great interest, as indicating the train of thought which must have occupied the mind of their author, and as proving that, in his latter days, he not only studied the doctrines of Christianity, but derived the greatest consolation from its tenets.

After some farther conversation, *Onuphrio* and *Ambrosio* leave their friend the author to pursue his meditations amidst the solitude of the ruins.

Seated in the moonshine on one of the steps leading to the seats supposed to have been occupied by the patricians in the Colosæum at the time of the public games, the train of ideas in which he had before indulged continued to flow with a vividness and force increased by the stillness and solitude of the scene, and by the full moon, which, he observes, has always a peculiar effect on these moods of feeling in his mind, giving to them a wildness and a kind of indefinite sensation, such as he supposes belong at all times to the true poetical temperament.

" It must be so," thought he,—" no new city will rise again out of the double ruins of this; no new empire will be founded upon these colossal remains of that of the old Romans. The world, like the individual, flourishes in youth, rises to strength in manhood, falls into decay in age; and the ruins of an empire are like the decrepid frame of an individual, except that they have some tints of beauty, which nature bestows upon them. The sun of civilization arose in the East, advanced towards the West, and is now at its meridian;—in a few centuries more, it will probably be seen sinking below the horizon, even in the new world; and there will be left darkness only where there is a bright light, deserts of sand where there were populous cities, and stagnant morasses where the green meadow, or the bright corn-field once appeared.—Time," he exclaimed, " which purifies, and, as it were, sanctifies the mind, destroys and brings into utter decay the body; and even in nature its influence seems always degrading. She is represented by the poet as eternal in her youth; but amongst these ruins she appears to me eternal in her age, and here, no traces of renovation appear in the ancient of days."

He had scarcely concluded this ideal sentence, when his reverie became deeper, and his imagination called up a spirit, who, having rebuked him for his ignorance and presumption, undeceives him in his views of the history of the world, by unfolding to him in a vision the progress of man from a state of barbarity to that of high civilization. He is first shown a country covered with forests and marshes; wild animals were grazing in large savannahs, and carnivorous beasts, such as lions and tigers, occasionally disturbing and destroying them. Man appeared as a naked savage, feeding upon wild fruits, or devouring shell-fish, or fighting with clubs for the remains of a whale which had been thrown upon the shore. His habitation was a cave in the earth— "See the birth of Time!" exclaimed the Genius; "look at man in his newly created state, full of youth and vigour. Do you see aught in this state to admire or envy?"

In the next scene, a country opened upon his view, which appeared partly wild and partly cultivated; and men were seen covered with the skins of animals, and driving cattle to enclosed pastures; others were reaping and collecting corn, and others again were making it into bread. Cottages appeared furnished with many of the conveniences of life. The Genius now said, "Look at these groups of men who are escaped from the state of infancy: they owe their improvement to a few superior minds still amongst them. That aged man whom you see with a crowd around him taught them to build cottages; from that other they learnt to domesticate cattle; from others, to collect and sow corn and seeds of fruit. And these arts will never be lost; another generation will see them more perfect. You shall be shown other visions of the passages of time; but as you are carried along the stream which flows from the period of creation to the present moment, I shall only arrest your transit to make you observe some circumstances which will demonstrate the truths I wish you to know." He then proceeds to describe in succession the different scenes as they appeared before him, and to relate the observations by which his genius, or intellectual guide, accompanied them.

A great extent of cultivated plains, large cities on the sea shore, palaces, forums, and temples, were displayed before him. He saw men associated in groups, mounted on horses, and performing military exercises; galleys moved by oars on the ocean; roads intersecting the country covered with travellers, and containing carriages moved by men or horses. The Genius now said, "You see the early state of civilization of man: the cottages of the last race you beheld have become improved into stately dwellings, palaces, and temples, in which use is combined with ornament. The few men to whom, as I said before, the foundations of these improvements were owing, have had divine honours paid to their memory. But look at the instruments belonging to this generation, and you will find they were only of brass. You see men who are talking to crowds around them, and others who are apparently amusing listening groups by a kind of song or recitation; these are the earliest bards and orators; but all their signs of thought are oral, for written language does not yet exist."

The Genius next presented to him a scene of varied business and imagery. He saw a man who bore in his hands the same instruments as our modern smiths, presenting a vase, which appeared to be made of iron, amidst the acclamations of an assembled multitude; and he saw in the same place men who carried rolls of papyrus in their hands, and wrote upon them with reeds containing ink, made from the soot of wood mixed with a solution of glue.—"See," the Genius said, "an immense change produced in the condition of society by the two arts of which you now see the origin; the one, that of rendering iron malleable, which is owing to a single individual, an obscure Greek; the other, that of making thought permanent in written characters,—an art which has gradually arisen from the hieroglyphics which you may observe on yonder pyramids. You will now see human life more replete with power and activity."

In the scenes that succeeded, he saw bronze instruments thrown away; malleable iron converted into hard steel, and applied to a thousand purposes of civilized life; bands of men traversing the sea, founding colonies, building cities, and, wherever they established themselves, carrying with them their peculiar arts. He saw the Roman world succeeded by cities filled with an idle and luxurious population, and the farms which had been cultivated by warriors, who left the plough to take the command of armies, now in the hands of slaves; and the militia of free men supplanted by bands of mercenaries, who sold the Empire to the highest bidder. He saw immense masses of warriors collecting in the North and East, carrying with them no other proofs of cultivation but their horses and steel arms. He saw these savages every where plundering cities and destroying the monuments of arts and literature. Ruin, desolation, and darkness were before him, and he closed his eyes to avoid the melancholy scene. "See," said the Genius, "the termination of a power believed by its founders invincible, and intended to be eternal. But you will find, though the glory and greatness belonging to its military genius have passed away, yet those belonging to the arts and institutions by which it adorned and dignified life, will again arise in another state of society."

Upon again opening his eyes, he saw Italy recovering from her desolation, towns arising with governments almost upon the model of ancient Athens and

Rome, and these different small states rivals in arts and arms;—he saw the remains of libraries, which had been preserved in monasteries and churches by a holy influence which even the Goth and Vandal respected, again opened to the people;—he saw Rome rising from her ashes, the fragments of statues found amidst the ruins of her palaces and imperial villas, becoming the models for the regeneration of art;—he saw magnificent temples raised in this city become the metropolis of a new and Christian world, and ornamented with the most brilliant master-pieces of the arts of design.—"Now," the Genius said, "society has taken its modern and permanent aspect. Consider for a moment its relations to letters and to arms, as contrasted with those of the ancient world." He looked, and he saw that, in the place of the rolls of papyrus, libraries were now filled with books. "Behold," the Genius said, "THE PRINTING PRESS! By the invention of Faust, the productions of genius are, as it were, made imperishable, capable of indefinite multiplication, and rendered an unalienable heritage of the human mind. By this art, apparently so humble, the progress of society is secured, and man is spared the humiliation of witnessing again scenes like those which followed the destruction of the Roman Empire. Now look to the warriors of modern times; you see the spear, the javelin, and the cuirass are changed for the musket and the light artillery. The German monk who discovered gunpowder did not meanly affect the destinies of mankind; wars are become less bloody by becoming less personal; mere brutal strength is rendered of comparatively little avail; all the resources of civilization are required to move a large army; wealth, ingenuity, and perseverance become the principal elements of success; civilized man is rendered in consequence infinitely superior to the savage, and gunpowder gives permanence to his triumph, and secures the cultivated nations from being ever again overrun by the inroads of millions of barbarians."*

The Genius then directs his attention to scenes in which are displayed the triumphs of modern science; such as the steam-engine, and the thousand resources furnished by the chemical and mechanical arts; and she concludes by endeavouring to impress upon him the conviction "That the results of intel-

* This is a question which Gibbon has very eloquently discussed ("*General Observations on the Fall of the Roman Empire in the West*," vol. vi.) "Cannon and fortifications now form an impregnable barrier against the Tartar horse; and Europe is secure from any future irruption of barbarians; since, before they can conquer, they must cease to be barbarous." What an extraordinary illustration does this principle find in the history of our possessions in India, where, to speak in round numbers, thirty thousand Europeans keep no less than one hundred million of natives in subjection!

lectual labour, or of scientific genius, are permanent, and incapable of being lost. Monarchs change their plans, governments their objects, a fleet or an army effect their purpose and then pass away ; but a piece of steel touched by the magnet preserves its character for ever, and secures to man the dominion of the trackless ocean. A new period of society may send armies from the shores of the Baltic to those of the Euxine, and the empire of the followers of Mahomet may be broken in pieces by a Northern people, and the dominion of the Britons in Asia may share the fate of Tamerlane or Zengis-khan ; but the steam-boat which ascends the Delaware, or the St. Lawrence, will be continued to be used, and will carry the civilization of an improved people into the deserts of North America, and into the wilds of Canada. In the common history of the world, as compiled by authors in general, almost all the great changes of nations are confounded with changes in their dynasties, and events are usually referred either to sovereigns, chiefs, heroes, or their armies, which do, in fact, originate from entirely different causes, either of an intellectual or moral nature."

Having instructed him in the history of man as an inhabitant of the earth, the Genius proceeds to reveal to him the mysteries of spiritual natures, in which the author evidently shows his attachment to the belief that our intellectual essence is destined hereafter to enjoy a higher and better state of planetary existence,* drinking intellectual light from a purer source, and approaching nearer to the infinite and Divine mind. I shall not attempt to follow him and his Genius to the verge of the solar system, witnessing in his career the inhabitants of planets and comets. We may upon this occasion truly apply to the author the words of Lucretius —

> " Processit longe flammantia mœnia mundi."
>
> " His vigorous and active mind was hurl'd
> Beyond the flaming limits of the world."—Creech.

In the former part of the dialogue, his poetical coruscations appeared only as brilliant sparks thrown off by the rapidity of the machinery which he worked for a useful end and for a definite purpose; his vivid imagination may now be compared to a display of fire-works, which dazzle and confound

* Under the article 'Sensation,' in the Philosophical Dictionary, we find Voltaire indulging in a similar speculation. " It may be, that in other globes the inhabitants possess sensations of which we can form no idea. It is possible that the number of our senses augments from globe to globe, and that an existence with innumerable and perfect senses will be the final attainment of all being."

without enlightening the senses, and leave the spectator in still more profound darkness.

His Second Dialogue, entitled "Discussions connected with the Vision in the Colosæum," may be considered as a commentary upon the views he had unfolded; and a more appropriate spot, perhaps, could not have been selected for a conversation upon the progress of civilization, than the summit of Vesuvius, from which, to adopt the language of *Ambrosio*, "We see not only the power and activity of man as existing at present, and of which the highest example may be represented by the steam-boat departing from Palermo, but we may likewise view scenes which carry us into the very bosom of antiquity, and as it were make us live with the generations of past ages."

The author, who assumes throughout this dialogue the name of *Philalethes*, after having been duly rallied by his friends on the subject of his vision, thus expresses himself:—"I will acknowledge that the vision in the Colosæum is a fiction; but the most important parts of it really occurred to me in sleep, particularly that in which I seemed to leave the earth and launch into the infinity of space, under the guidance of a tutelary genius. And the origin and progress of civil society form likewise parts of another dream which I had many years ago; and it was in the reverie which happened when you quitted me in the Colosæum, that I wove all these thoughts together, and gave them the form in which I narrated them to you.—I do not say that they are strictly to be considered as an accurate representation of my waking thoughts; for I am not quite convinced that dreams are always the representations of the state of the mind, modified by organic diseases or by associations. There are certainly no absolutely new ideas produced in sleep; yet I have had more than one instance, in the course of my life, of most extraordinary combinations occurring in this state, which have had considerable influence on my feelings, my imagination, and my health."

Philalethes now relates a fact to which his preceding observation more immediately referred; he anticipates unbelief,—but he declares that he mentions nothing but a simple fact.

"Almost a quarter of a century ago, I contracted that terrible form of typus fever known by the name of jail fever,—I may say, not from any imprudence of my own, but whilst engaged in putting in execution a plan for ventilating one of the great prisons of the metropolis.* My illness was severe and

* See page 183, for an account of this event.

dangerous; as long as the fever continued, my dreams and deliriums were most painful and oppressive; but when weakness consequent to exhaustion came on, and when the probability of death seemed to my physicians greater than that of life, there was an entire change in all my ideal combinations. I remained in an apparently senseless or lethargic state, but, in fact, my mind was peculiarly active; there was always before me the form of a beautiful woman, with whom I was engaged in the most interesting and intellectual conversation."

Ambrosio and *Onuphrio* very naturally suggest that this could have been no other than the image of some favourite maiden which had haunted his imagination; but *Philalethes* rejects with indignation such an explanation of the vision. "I will not," he exclaims, "allow you to treat me with ridicule on this point, till you have heard the second part of my tale. Ten years after I had recovered from the fever, and when I had almost lost the recollection of the vision, it was recalled to my memory by a very blooming and graceful maiden fourteen or fifteen years old, that I accidentally met during my travels in Illyria; but I cannot say that the impression made upon my mind by this female was very strong. Now comes the extraordinary part of the narrative: ten years after,—twenty years after my first illness, at a time when I was exceedingly weak from a severe and dangerous malady, which for many years threatened my life, and when my mind was almost in a desponding state, being in a course of travels ordered by my medical advisers, I again met the person who was the representative of my visionary female; and to her kindness and care, I believe, I owe what remains to me of existence. My despondency gradually disappeared, and though my health still continued weak, life began to possess charms for me which I had thought were for ever gone; and I could not help identifying the living angel with the vision which appeared as my guardian genius during the illness of my youth."

The reader will probably agree with *Onuphrio,* in seeing in this history nothing beyond the influence of an imagination excited by disease.

The discourse now turns upon that part of the vision in the Colosæum in which was exhibited the early state of man, after his first creation, and which *Ambrosio* considers as not only incompatible with revelation, but likewise with reason and every thing that we know respecting the history or traditions of the early nations of antiquity.

I shall merely state the objection which *Ambrosio* offers. I must then refer the reader to the work itself for an account of the discussion it provoked.

"*Ambrosio.*—You consider man, in his early state, a savage like those who now inhabit New Holland, or New Zealand, acquiring, by the little use that they make of a feeble reason, the power of supporting and extending life. Now, I contend that, if man had been so created, he must inevitably have been destroyed by the elements or devoured by savage beasts, so infinitely his superiors in physical force."

During the discussion, an opinion is advanced by *Ambrosio,* so singular, that I must be allowed to quote it. "I consider," says he, "all the miraculous parts of our religion as effected by changes in the sensations or ideas of the human mind, and not by physical changes in the order of nature! To infinite wisdom and power, a change in the intellectual state of the human being may be the result of a momentary will, and the mere act of faith may produce the change. How great the powers of imagination are, even in ordinary life, is shown by many striking facts, and nothing seems impossible to this imagination when acted upon by divine influence."

This is surely a most extraordinary line of argument for the apologist of the Christian faith, and of the miracles by which it is supported.

In the Third Dialogue, called the Unknown, the author and his friends, *Ambrosio* and *Onuphrio,* make an excursion to the remains of the temples of Pæstum. "Were my existence to be prolonged through ten centuries," exclaims the author, "I think I could never forget the pleasure I received on that delicious spot." In contemplating beautiful scenery, much of its interest depends upon the feelings and associations of the moment; and the author was upon this occasion evidently in that poetical frame of mind which sheds a magic light over every landscape, and converts the most ordinary objects into emblems of morality: in the admixture of the olive and the cypress tree, he saw a connection, to memorialize, as it were, how near each other are life and death, joy and sorrow; while the music of the birds, and above all the cooing of the turtle-doves, by overpowering the murmuring of the waves and the whistling of the winds, served but to show him that, in the strife of nature, the voice of love is predominant.

With their hearts touched by the scene they had witnessed, the travellers descended to the ruins, and began to examine those wonderful remains which have outlived even the name of the people by whom they were raised. While engaged in measuring the Doric columns in the interior of the Temple of Neptune, a stranger, remarkable both in dress and appearance, was observed to be writing in a memorandum book; the author immediately addresses him, and becoming mutually pleased with each other, they enter into a conversation of high scientific interest.

The sentiments delivered by the "UNKNOWN," for by this title is the philosopher designated, notwithstanding their dramatic dress, are evidently to be received as the bequest of the latest scientific opinions of Sir H. Davy upon several important subjects, and must consequently command our respect and consideration.

To a question relative to the nature of the masses of travertine, of which the ruins consisted, the Unknown replied, that they were certainly produced by deposition from water; and he rather believed, that a lake in the immediate neighbourhood of the city furnished the quarry. The party are then described as visiting this spot.

"There was something peculiarly melancholy in the character of this water; all the herbs around it were grey, as if encrusted with marble; a few buffaloes were slaking their thirst in it, which ran wildly away at our approach, and appeared to retire into a rocky excavation or quarry at the end of the lake. 'There,' said the stranger, 'is what I believe to be the source of those large and durable stones which you see in the plain before you. This water rapidly deposits calcareous matter, and even, if you throw a stick into it, a few hours is sufficient to give it a coating of this substance. Whichever way you turn your eyes, you see masses of this recently produced marble, the consequence of the overflowing of the lake during the winter floods.'

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"This water is like many, I may say most, of the sources which rise at the foot of the Apennines; it holds carbonic acid in solution, which has dissolved a portion of the calcareous matter of the rock through which it has passed:—this carbonic acid is dissipated in the atmosphere, and the marble, slowly thrown down, assumes a crystalline form and produces coherent stones. The lake before us is not particularly rich in the quantity of calcareous matter, for, as I have found by experience, a pint of it does not afford more than five or six grains; but the quantity of fluid and the length of time are sufficient to account for the immense quantities of tufa and rock which, in the course of ages, have accumulated in this situation."

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"It can, I think, be scarcely doubted that there is a source of volcanic fire at no great distance from the surface, in the whole of southern Italy; and, this fire acting upon the calcareous rocks of which the Apennines are composed, must constantly detach from them carbonic acid, which rising to the sources of the springs, deposited from the waters of the atmosphere, must give them their impregnation, and enable them to dissolve calcareous matter. I need not dwell upon Etna, Vesuvius, or the Lipari Islands, to prove that volcanic fires are still in existence; and there can be no doubt that, in earlier periods, almost the whole of Italy was ravaged by them; even Rome itself, the eternal city, rests upon the craters of extinct volcanoes; and I imagine that the traditional and fabulous record of the destruction made by the conflagration of Phaeton, in the chariot of the Sun, and his falling into the Po, had reference to a great and tremendous igneous volcanic eruption which extended over Italy, and ceased only near the Po, at the foot of the Alps. Be this as it may, the sources of carbonic acid are numerous, not merely in the Neapolitan but likewise in the Roman and Tuscan states. The most magnificent waterfall in Europe, that of the Velino near Terni, is partly fed by a stream containing calcareous matter dissolved by carbonic acid, and it deposits marble, which crystallizes even in the midst of its thundering descent and foam, in the bed in which it falls.

"There is a lake in Latium, a few yards above the Lacus Albula, where the ancient Romans erected their baths, which sends down a considerable stream of tepid water to the larger lake; but this water is less strongly impregnated with carbonic acid; the largest lake is actually a saturated solution of this gas, which escapes from it in such quantities in some parts of its surface, that it has the appearance of being actually in ebullition. Its temperature I ascertained to be, in the winter, in the warmest parts, above 80 degrees of Fahrenheit, and as it appears to be pretty constant, it must be supplied with heat from a subterraneous source, being nearly twenty degrees above the mean temperature of the atmosphere. Kircher has detailed, in his *Mundus Subterraneus*, various wonders respecting this lake, most of which are unfounded; such as, that it is unfathomable,—that it has at the bottom the heat of boiling water, and that floating islands rise from the gulf which emits it. It must certainly be very difficult, or even impossible, to fathom a source which rises with so much violence from a subterraneous excavation; and at a time when chemistry had made small progress, it was easy to mistake the disengagement of carbonic acid for an actual ebullition. The floating islands are real; but neither the Jesuit, nor any of the writers who have since described this lake, had a correct idea of their origin, which is exceedingly curious. The high temperature of this water, and the quantity of carbonic acid that it contains, render it peculiarly fitted to afford a pabulum or nourishment to vegetable life; the banks of travertine are every where covered with reeds, lichens, confervæ, and various kinds of aquatic vegetables; and at the same time that the process of vegetable life is going on, the crystallizations of the calcareous matter, which is every where deposited in consequence of the escape of carbonic acid, likewise proceed, giving a constant milkiness to what from its tint would otherwise be a blue fluid. So rapid is the vegetation, owing to the decomposition of the carbonic acid, that even in winter, masses of confervæ and lichens, mixed with deposited travertine, are constantly detached by the current of water from the bank, and float down the stream, which being a considerable river, is never without many of these small islands on its surface; they are sometimes only a few inches in size, and composed merely of dark green confervæ, or purple or yellow lichens; but they are sometimes even of some feet in diameter, and contain seeds and various species of common water-plants, which are usually more or less incrusted with marble. There is, I believe, no place in the world where there is a more striking example of the opposition or contrast of the laws of animate and inanimate nature, of the forces of inorganic chemical affinity and those of the powers of life. Vegetables, in such a temperature, and every where surrounded by food, are produced with a wonderful rapidity; but the crystallizations are formed with equal quickness, and they are no sooner produced than they are destroyed together. The quantity of vegetable matter and its heat make it the resort of an infinite variety of insect tribes; and, even in the coldest days in winter, numbers of flies may be observed on the vegetables surrounding its banks or on its floating islands, and a quantity of their larvæ may be seen there, sometimes incrusted and entirely destroyed by calcareous matter, which is likewise often the fate of the insects themselves, as well as of various species of shell-fish that are found amongst the vegetables which grow and are destroyed in the travertine on its banks."

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"I have passed many hours, I may say, many days, in studying the phenomena of this wonderful lake; it has brought many trains of thought into my mind connected with the early changes of our globe, and I have sometimes reasoned from the forms of plants and animals preserved in marble in this warm source, to the grander depositions in the secondary rocks, where the zoophytes or coral insects have worked upon a grand scale, and where palms and vegetables now unknown are preserved with the remains of crocodile, turtles, and gigantic extinct animals of the *Sauri* genus, and which appear to have belonged to a period when the whole globe possessed a much higher temperature.

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"Then, from all we know, this lake, except in some change in its dimensions, continues nearly in the same state in which it was described seventeen hundred years ago by Pliny, and I have no doubt contains the same kinds of floating islands, the same plants, and the same insects. During the fifteen years that I have known it, it has appeared precisely identical in these respects; and yet it has the character of an accidental phenomenon depending upon subterraneous fire. How marvellous then are those laws by which even the humblest types of organic existence are preserved, though born amidst the sources of their destruction, and by which a species of immortality is given to generations, floating, as it were, like evanescent bubbles on a stream raised from the deepest caverns of the earth, and instantly losing what may be called its spirit in the atmosphere!"

From this interesting discourse on the formation of Travertine, the conversation naturally turned to Geology; and I shall here again be compelled to give another copious extract, in order to show what were the latest opinions of Sir H. Davy upon this subject. If any doubt could exist as to the views here given being those entertained by the author, it is at once removed by his letter to Mr. Poole, in which, alluding to the work under review, he says, "*It contains the essence of my philosophical opinions.*"

"On the geological scheme of the early history of the globe, there are only analogies to guide us, which different minds may apply and interpret in different ways; but I will not trifle with a long preliminary discourse. Astronomical deductions and actual measures by triangulation prove that the globe is an oblate spheroid flattened at the poles; and this form, we know, by strict mathematical demonstrations, is precisely the one which a fluid body revolving round its axis and become solid at its surface by the slow dissipation of its heat or other causes, would assume. I suppose, therefore, that the globe, in the first state in which the imagination can venture to consider it, was a fluid mass with an immense atmosphere, revolving in space round the sun, and that by its cooling, a portion of its atmosphere was condensed in water which occupied a part of the surface. In this state, no forms of life, such as now belong to our system, could have inhabited it; and I suppose the crystalline rocks, or, as they are called by geologists, the *primary* rocks, which contain no vestiges of a former order of things, were the results of the first consolidation on its surface. Upon the farther cooling, the water which more or less had covered it contracted; depositions took place, shell-fish, and coral insects of the first creation began their labours, and islands appeared in the midst of the ocean, raised from the deep by the productive energies of millions of zoophytes. These islands became covered with vegetables fitted to bear a high temperature, such as palms, and various species of plants similar to those which now exist in the hottest part of the world. And the submarine rocks or shores of these new formations of land became covered with aquatic vegetables, on which various species of shell-fish and common fishes found their nourishment. The fluids of the globe in cooling deposited a large quantity of the materials they held in solution, and these deposits agglutinating together the sand, the immense masses of coral rocks, and some of the remains of the shells and fishes found round the shores of the primitive lands, produced the first order of *secondary* rocks.

"As the temperature of the globe became lower, species of the oviparous reptiles were created to inhabit it; and the turtle, crocodile, and various gigantic animals of the *Sauri* kind seem to have haunted the bays and waters of the primitive lands. But in this state of things there was no order of events similar to the present,—the crust of the globe was exceedingly slender, and the source of fire a small distance from the surface. In consequence of contraction in one part of the mass, cavities were opened, which caused the entrance of water, and immense volcanic explosions took place, raising one part of the surface, depressing another, producing mountains and causing new and extensive depositions from the primitive ocean. Changes of this kind must have been extremely frequent in the early epochas of nature; and the only living forms of which the remains are found in the strata that are the monuments of these changes, are those of plants, fishes, birds, and oviparous reptiles, which seem most fitted to exist in such a war of the elements.

"When these revolutions became less frequent; and the globe became still more cooled, and the inequalities of its temperature preserved by the mountain chains, more perfect animals became its inhabitants, many of which, such as the mammoth, megalonix, megatherium, and gigantic hyena, are now extinct. At this period, the temperature of the ocean seems to have been not much higher than it is at present, and the changes produced by occasional eruptions of it have left no consolidated rocks. Yet one of these eruptions appears to have been of great extent and of some duration, and seems to have been the cause of those immense quantities of water-worn stones, gravel, and sand, which are usually called *diluvian* remains;—and it is probable that this effect was connected with the elevation of a new continent in the southern hemisphere by volcanic fire. When the system of things became so permanent, that the tremendous revolutions depending upon the destruction of the equilibrium between the heating and cooling agencies were no longer to be dreaded, the creation of man took place; and since that period there has been little alteration in the physical circumstances of our globe. Volcanoes sometimes occasion the rise of new islands, portions of the old continents are constantly washed by rivers into the sea, but these changes are too insignificant to affect the destinies of man, or the nature of the physical circumstances of things. On the hypothesis that I have adopted, however, it must be remembered, that the present surface of the globe is merely a thin crust surrounding a nucleus of fluid ignited matter; and consequently, we can hardly be considered as actually safe from the danger of a catastrophe by fire."

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"I beg you to consider the views I have been developing as merely hypothetical, one of the many resting-places that may be taken by the imagination in considering this subject. There are, however, distinct facts in favour of the idea, that the interior of the globe has a higher temperature than the surface; the heat increasing in mines the deeper we penetrate, and the number of warm sources which rise from great depths, in almost all countries, are certainly favourable to the idea. The opinion, that volcanoes are owing to this general and simple cause, is I think likewise more agreeable to the analogies of things, than to suppose them dependant upon partial chemical changes, such as the action of air and water upon the combustible bases of the earths and alkalies, though it is extremely probable that these substances may exist beneath the surface, and may occasion some results of volcanic fire;—and on this subject my notion may perhaps be the more trusted, as for a long while I thought volcanic eruptions were owing to chemical agencies of the newly discovered metals of the earths and alkalies, and I made many and some dangerous experiments in the hope of confirming this notion, but in vain."

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"I have no objection to the '*refined Plutonic view*,' (of Professor Playfair and Sir James Hall) as capable of explaining many existing phenomena; indeed, you must be aware that I have myself had recourse to it. What I contend against is, its application to explain the formations of the secondary rocks, which I think clearly belong to an order of facts not at all embraced by it. In the Plutonic system, there is one simple and constant order assumed, which may be supposed eternal. The surface is constantly imagined to be disintegrated, destroyed, degraded, and washed into the bosom of the ocean by water, and as constantly consolidated, elevated, and regenerated by fire; and the ruins of the old form the foundations of the new world. It is supposed that there are always the same types both of dead and living matter,—that the remains of rocks, of vegetables, and animals of one age are found imbedded in rocks raised from the bottom of the ocean in another. Now, to support this view, not only the remains of living beings which at present people the globe, might be expected to be found in the oldest secondary strata, but even those of the art of man, the most powerful and populous of its inhabitants, which is well known not to be the case. On the contrary, each stratum of the secondary rocks contains remains of peculiar and mostly now unknown species of vegetables and animals. In those strata which are deepest, and which must consequently be supposed to be the earliest deposited, forms even of vegetable life are rare; shells and vegetable remains are found in the next order; the bones of fishes and oviparous reptiles exist in the following class; the remains of birds, with those of the same genera mentioned before, in the next order; those of quadrupeds of extinct species in a still more recent class; and it is only in the loose and slightly consolidated strata of gravel and sand, and which are usually called diluvian formations, that the remains of animals, such as now people the globe, are found, with others belonging to extinct species. But in none of these formations, whether called secondary, tertial, or diluvial, have the remains of man, or any of his works, been discovered. It is, I think, impossible to consider the organic remains found in any of the earlier secondary strata, the lias-limestone and its congenerous formations, for instance, without being convinced, that the beings whose organs they formed belonged to an order of things entirely different from the present. Gigantic vegetables, more nearly allied to the palms of the equatorial countries than to any other plants, can only be imagined to have lived in a very high temperature; and the immense reptiles, the *Megalosauri*, with paddles instead of legs, and clothed in mail, in size equal, or even superior to the whale; and the great amphibia *Plethiosauri*, with bodies like turtles, but furnished with necks longer than their bodies, probably to enable them to feed on vegetables growing in the shallows of the primitive ocean, seem to show a state in which low lands, or extensive shores, rose above an immense calm sea, and when there were no great mountain chains to produce inequalities of temperature, tempests, or storms. Were the surface of the earth now to be carried down into the depths of the ocean, or were some great revolution of the waters to cover the existing land, and it was again to be elevated by fire, covered with consolidated depositions of sand or mud, how entirely different would it be in its characters from any of the secondary strata; its great features would undoubtedly be the works of man; hewn stones, and statues of bronze and marble, and tools of iron, and human remains, would be more common than those of animals, on the greatest part of the surface; the columns of Pæstum, or of Agrigentum, or the immense iron bridges of the Thames, would offer a striking contrast to the bones of the crocodiles or *Sauri*, in the older rocks, or even to those of the mammoth, or *Elephas primogenius*, in the diluvial strata. And whoever dwells upon this subject must be convinced, that the present order of things, and the comparatively recent existence of man, as the master of the globe, is as certain as the destruction of a former and a different order, and the extinction of a number of living forms, which have now no types in being, and which have left their remains wonderful monuments of the revolutions of nature."

The Fourth Dialogue, to which is given the title of "The Proteus, or Immortality," is of a more desultory nature than those which precede it. It contains many beautiful descriptions of scenery in the Alpine country of Austria; furnishes an interesting account of that most singular reptile the *Proteus Anguinus*, which is found only in the limestone caverns of Carniola, and concludes with reflections upon the indestructibility of the sentient principle.

The author's companion, during the tour he describes, is a scientific friend, whom he calles *Eubathes*. The dialogue opens with a passage of considerable pathos and eloquence; the author having been recalled to England by a melancholy event, the death of a very near and dear relation, describes his feelings on entering London.

"In my youth, and through the prime of manhood, I never entered London without feelings of pleasure and hope. It was to me as the grand theatre of intellectual activity, the field of every species of enterprise and exertion, the metropolis of the world of business, thought, and action. There, I was sure to find the friends and companions of my youth, to hear the voice of encouragement and praise. There, society of the most refined kind offered daily its banquets to the mind, with such variety that satiety had no place in them, and new objects of interest and ambition were constantly exciting attention either in politics, literature, or science.

"I now entered this great city in a very different tone of mind—one of settled melancholy, not merely produced by the mournful event which recalled me to my country, but owing likewise to an entire change in the condition of my physical, moral, and intellectual being. My health was gone, my ambition was satisfied; I was no longer excited by the desire of distinction; what I regarded most tenderly was in the grave; and to take a metaphor, derived from the change produced by time in the juice of the grape, my cup of life was no longer sparkling, sweet, and effervescent; it had lost its sweetness without losing its power, and it had become bitter."

There is perhaps not a more splendid passage to be found in the work; and it is scarcely inferior to Dr. Johnson's memorable conclusion to the preface of his Dictionary.

"After passing a few months in England," says he, "and enjoying (as much as I could enjoy any thing) the society of the few friends who still remained alive, the desire of travel again seized me. I had preserved amidst the wreck of time, one feeling strong and unbroken—the love of natural scenery; and this, in advanced life, formed a principal motive for my plans of conduct and action."

The fall of the Traun, about ten miles below Gmünden, was one of his favourite haunts; and he describes an accident of the most awful description which befell him at this place. While amusing himself on the water by a rapid species of locomotion, in a boat so secured by a rope as to allow only of a limited range, the tackle gave way, and he was rapidly precipitated down the cataract. He remained for some time after his rescue in a state of insensibility, and on recovering found himself attended by his mysterious friend, the "Unknown," who had so charmed him in his excursion to Pæstum.

With this stranger, he proceeded on his tour; and he again becomes the medium through which much philosophical information is conveyed to the reader.

They visit together the grotto of the Maddalena at Adelsberg, and he gives us the conversation that took place in that extraordinary cavern.

"*Philalethes.*—If the awful chasms of dark masses of rock surrounding us appear like the work of demons, who might be imagined to have risen from the centre of the earth, the beautiful works of nature above our heads may be compared to a scenic representation of a temple or banquet-hall for fairies or genii, such as those fabled in the Arabian romances.

" *The Unknown.*—A poet might certainly place here the palace of the king of the Gnomes, and might find marks of his creative power in the small lake close by, on which the flame of the torch is now falling; for, there it is that I expect to find the extraordinary animals which have been so long the objects of my attention.

" *Eubathes.*—I see three or four creatures, like slender fish, moving on the mud below the water.

" *The Unknown.*—I see them; they are the Protei,—now I have them in my fishing-net, and now they are safe in the pitcher of water. At first view, you might suppose this animal to be a lizard, but it has the motions of a fish. Its head, and the lower part of its body and its tail bear a strong resemblance to those of the eel; but it has no fins; and its curious bronchial organs are not like the gills of fishes; they form a singular vascular structure, as you see, almost like a crest, round the throat, which may be removed without occasioning the death of the animal, who is likewise furnished with lungs. With this double apparatus for supplying air to the blood, it can live either below or above the surface of the water. Its fore-feet resemble hands, but they have only three claws or fingers, are too feeble to be of use in grasping, or supporting the weight of the animal; the hinder feet have only two claws or toes, and in larger specimens are found so imperfect as to be almost obliterated. It has small points in place of eyes, as if to preserve the analogy of nature. Its nasal organs appear large; and it is abundantly furnished with teeth, from which it may be concluded, that it is an animal of prey; yet in its confined state it has never been known to eat, and it has been kept alive for many years by occasionally changing the water in which it is placed.

" *Eubathes.*—Is this the only place in Carniola where these animals are found?

" *The Unknown.*—They were first discovered here by the late Baron Zois; but they have since been found, though rarely, at Sittich, about thirty miles distant, thrown up by water from a subterraneous cavity; and I have lately heard it reported that some individuals of the same species have been recognised in the calcareous strata in Sicily. I think it cannot be doubted, that their natural residence is an extensive deep subterranean lake, from which in great floods they sometimes are forced through the crevices of the rocks into this place where they are found; and it does not appear to me impossible, when the peculiar nature of the country in which we are is considered, that the same great cavity may furnish the individuals which have been found at Adelsberg and at Sittich.

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"This adds one more instance to the number already known of the wonderful manner in which life is produced and perpetuated in every part of our globe, even in places which seem the least suited to organized existence. And the same infinite power and wisdom which has fitted the camel and the ostrich for the deserts of Africa, the swallow that secretes its own nest for the caves of Java, the whale for the Polar seas, and the morse and white bear for the Arctic ice, has given the Proteus to the deep and dark subterraneous lakes of Illyria,—an animal to whom the presence of light is not essential, and who can live indifferently in air and in water, on the surface of the rock, or in the depths of the mud."

Much interesting physiological discussion follows. I shall, however, merely notice the opinion delivered by the "Unknown," on the subject of respiration, and which I think shows that, at the conclusion of his career, Davy entertained the same notions, with regard to the communication of some ethereal principle to the blood, as he maintained in the earlier part of his life.*—"The obvious chemical alteration of the air is sufficiently simple in this process; a certain quantity of carbon only is added to it, and it receives an addition of heat or vapour; the volumes of elastic fluid inspired and expired (making allowance for change of temperature,) are the same, and if ponderable agents only were to be regarded, it would appear as if the only use of respiration were to free the blood from a certain quantity of carbonaceous matter. But it is probable that this is only a secondary object, and that the change produced by respiration upon the blood is of a much more important kind. Oxygen, in its elastic state, has properties which are very characteristic; it gives out light by compression, which is not certainly known to be the case with any other elastic fluid except those which oxygen has entered without undergoing combustion; and from the fire it produces in certain processes, and from the manner in which it is separated by positive electricity in the gaseous state from its combinations, it is not easy to avoid the supposition, that it contains, besides its ponderable elements, some very subtile matter which is capable of assuming the form of heat and light. *My idea* is, that the

* See page 49.

common air inspired enters into the venous blood entire, in a state of dissolution, carrying with it its subtile or ethereal part, which in ordinary cases of chemical change is given off; that it expels from the blood carbonic acid gas and azote; and that, in the course of the circulation, its ethereal part and its ponderable part undergo changes which belong to laws that cannot be considered as chemical, — the ethereal part probably producing animal heat and other effects, and the ponderable part contributing to form carbonic acid and other products. The arterial blood is necessary to all the functions of life, and it is no less connected with the irritability of the muscles and the sensibility of the nerves than with the performance of all the secretions."

The FIFTH DIALOGUE is entitled "The Chemist." Its object is to demonstrate the importance of this noble science. An interlocutor is made to disparage its utility, and to mark its weaker points. These of course are answered, the sceptic becomes a true believer, and the intellectual gladiators separate mutually satisfied with each other.

"*Eubathes.*—I feel disposed to join you in attacking this favourite study of our friend, *but merely* to provoke him to defend it, in order to call forth his skill and awaken his eloquence.

"*The Unknown.*—I have no objection. Let there be a fair discussion; remember, we fight only with foils, and the point of mine shall be covered with velvet."

After having enumerated the scientific attainments necessary to constitute the chemist, and described the apparatus essential for understanding what has been already done in the science, he proceeds to define the intellectual qualities which he considers necessary for discovery, or for the advancement of the science. Amongst them, patience, industry, and neatness in manipulation, and accuracy and minuteness in observing and registering the phenomena which occur, are essential. A steady hand and a quick eye are most useful auxiliaries; but there have been very few great chemists who have preserved these advantages through life; for the business of the laboratory is often a service of danger, and the elements, like the refractory spirits of romance, though the obedient slaves of the magician, yet sometimes escape the influence of his talisman, and endanger his person. Both the hands and eyes of others, however, may be sometimes advantageously made use of. By often repeating a process or an observation, the errors connected with hasty operations or imperfect views are annihilated; and, provided the assistant has no preconceived notions of his own, and is ignorant of the object of his employer in making the experiment, his simple and bare detail of facts will often be the best foundation for an opinion. With respect to the higher qualities of intellect necessary for understanding and developing the general laws of the science, the same talents, I believe, are required as for making advancement in every other department of human knowledge; I need not be very minute. The imagination must be active and brilliant in seeking analogies; yet entirely under the influence of the judgment in applying them. The memory must be extensive and profound; rather, however, calling up general views of things than minute trains of thought;—the mind must not be like an Encyclopedia,—a burthen of knowledge, but rather a critical Dictionary, which abounds in generalities, and points out where more minute information may be obtained.

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" In announcing even the greatest and most important discoveries, the true philosopher will communicate his details with modesty and reserve; he will rather be a useful servant of the public, bringing forth a light from under his cloak when it is needed in darkness, than a charlatan exhibiting fireworks, and having a trumpeter to announce their magnificence.

" I see you are smiling, and think what I am saying in bad taste; yet, notwithstanding, I will provoke your smiles still farther, by saying a word or two on his other moral qualities. That he should be humble-minded, you will readily allow, and a diligent searcher after truth, and neither diverted from this great object by the love of transient glory or temporary popularity, looking rather to the opinion of ages, than to that of a day, and seeking to be remembered and named rather in the epochas of historians than in the columns of newspaper writers or journalists. He should resemble the modern geometricians in the greatness of his views and the profoundness of his researches, and the ancient alchemists in industry and piety. I do not mean that he should affix written prayers and inscriptions* of recommendations of his processes to Providence, as was the custom of Peter Wolfe, who was alive in my early days; but his mind should always be awake to devotional feelings; and in contemplating the variety and the beauty of the external world, and developing its scientific wonders, he will always refer to that infinite wisdom, through whose beneficence he is permitted to enjoy knowledge; and, in be-

* In illustration of the pious custom here alluded to by Sir H. Davy, it may be observed, that the vessels of the alchemists very commonly bore some emblem; such, for instance, as that of the cross; and from which, indeed, the word *crucible* derived its appellation.

coming wiser, he will become better,—he will rise at once in the scale of intellectual and moral existence, his increased sagacity will be subservient to a more exalted faith, and in proportion as the veil becomes thinner through which he sees the causes of things, he will admire more the brightness of the divine light by which they are rendered visible."

The Sixth and last Dialogue, entitled "Pola, or Time," presents a series of reflections, to which a view of the decaying amphitheatre at Pola, an ancient town in the peninsula of Istria, is represented as having given origin. On former occasions, the inspection of the mouldering works of past ages, called up trains of thought rather of a moral than of a physical character; in the present dialogue, the effects of time are considered in their relations to the mechanical and chemical laws by which material forms are destroyed, or rather changed,—for the author has shown by a number of beautiful examples, that without decay there can be no reproduction, and that the principle of change is a principle of life.

Having considered the influence of gravitation, the chemical and mechanical agencies of water, air, and electricity, and the energies of organized beings, in producing those diversified phenomena which, in our metaphysical abstractions, we universally refer to Time, he proceeds to enquire how far art can counteract their operation. A great philosopher, he observes, has said, "Man can in no other way command Nature but in obeying her laws:" it is evident that, by the application of some of those principles which she herself employs, we may for a while arrest the progress of changes which are ultimately inevitable.

"Yet, when all is done that can be done in the work of conservation, it is only producing a difference in the degree of duration. It is evident that none of the works of a mortal can be eternal, as none of the combinations of a limited intellect can be infinite. The operations of Nature, when slow, are no less sure; however man may, for a time, usurp dominion over her, she is certain of recovering her empire. He converts her rocks, her stones, her trees, into forms of palaces, houses, and ships; he employs the metals found in the bosom of the earth, as instruments of power, and the sands and clays which constitute its surface, as ornaments and resources of luxury; he imprisons air by water, and tortures water by fire to change, or modify, or destroy the natural forms of things. But in some lustrums his works begin to change, and in a few centuries they decay and are in ruins; and his mighty temples, framed as it were for immortal and divine purposes, and his bridges formed of granite and ribbed with iron, and his walls for defence, and the splendid monuments by which he has endeavoured to give eternity even to his perishable remains, are gradually destroyed; and these structures, which have resisted the waves of the ocean, the tempests of the sky, and the stroke of the lightning, shall yield to the operation of the dews of heaven,—of frost, rain, vapour, and imperceptible atmospheric influences; and as the worm devours the lineaments of his mortal beauty, so the lichens and the moss and the most insignificant plants shall feed upon his columns and his pyramids, and the most humble and insignificant insect shall undermine and sap the foundations of his colossal works, and make their habitations amongst the ruins of his palaces and the falling seats of his earthly glory."

On no occasion can such a subject be presented to a contemplative mind, without filling it with awe and wonder; but the circumstances under which these reflections are presented to us, in the last days of our philosopher, impress upon them an almost oracular solemnity. When we remember that while the mind of the philosopher was thus engaged in identifying the processes of decay with those of renovation in the system of nature, his body was palsied, and the current of his life fast ebbing, we cannot but admire that active intelligence which sparkled with such undiminished lustre amidst the wreck of its earthly tenement.

In the extracts which have been introduced from this last work, I trust the pledge that was given in the earlier part of these memoirs, has been redeemed, by showing that a powerful imagination is not necessarily incompatible with a sound judgment, that the flowers of fancy are not always blighted by the cold realities of science, but that the poet and philosopher may, under the auspices of a happy genius, mutually assist each other in expounding the mysteries of nature. It cannot be denied, as a general aphorism, that the tree which expands its force in flowers is generally deficient in fruit; but the mind of Davy, to borrow one of his own metaphors, may be likened to those fabled of the Hesperides, which produced at once buds, leaves, blossoms, and fruits.

The happy effects resulting from this rare and nicely adjusted combination of talents, offer themselves as interesting subjects of biographical contemplation, and they can be studied only with success by a comparative analysis of different minds.

That the superiority of Davy greatly depended upon the vivacity and compass of his imagination cannot be doubted, and such an opinion was well expressed by Mr. Davies Gilbert, in his late address to the Society:—"The poetic bent of Davy's mind seems never to have left him. To that circumstance I would ascribe the distinguishing features in his character and in his discoveries:—a vivid imagination sketching out new tracks in regions unexplored, for the judgment to select those leading to the recesses of abstract truth."

I have always thought that the mind of the late Dr. Clarke, the Mineralogical Professor of Cambridge, was little less imaginative than that of Davy, but it was deficient in judgment, and therefore often conducted him to error instead of to truth. Dr. Black was not deficient in imagination, and certainly not in judgment, but there was a constitutional apathy, arising probably from ill health, which damped his noblest efforts.

In addition to the anecdote already related of him, the following may serve to give a still greater force to this opinion. Soon after the appearance of Mr. Cavendish's paper on hydrogen gas, in which he made an approximation to the specific gravity of that body, showing that it was at least ten times lighter than common air, Dr. Black invited a party of his friends to supper, informing them that he had a curiosity to show them. Dr. Hutton and several others assembled, when having the allentois of a calf filled with hydrogen gas, upon setting it at liberty, it immediately ascended, and adhered to the ceiling. The phenomenon was easily accounted for: it was taken for granted that a small black thread had been attached to the allentois,—that this thread passed through the ceiling, and that some one in the apartment above, by pulling the thread, elevated it to the ceiling, and kept it in that position. This explanation was so probable, that it was acceded to by the whole company; though, like many other plausible theories, it was not true; for when the allentois was brought down, no thread whatever was found attached to it. Dr. Black explained the cause of the ascent to his admiring friends; but such was his unaccountable apathy, that he never gave the least account of this curious experiment even to his class; and more than twelve years elapsed before this obvious property of hydrogen gas was applied to the elevation of air balloons, by M. Charles, in Paris.*

It is by the rarity with which the talent of seizing upon remote analogies is associated with a spirit of patient and subtile investigation of details, and

* I am indebted for this anecdote to the "History of Chemistry," a very able work by Dr. Thomson, constituting the third number of the National Library.

a quick perception of their value, that the fact so truly stated by Mr. Babbage is to be explained: *viz.* that long intervals frequently elapse between the discovery of new principles in science and their practical application: thus he observes, that " the principle of the hydrostatic paradox was known as a speculative truth in the time of Stevinus, as far back as the year 1600,—and its application to raising heavy weights has long been stated in elementary treatises on natural philosophy, as well as constantly exhibited in lectures; yet it may fairly be regarded as a mere abstract principle, until the late Mr. Bramah, by substituting a pump, instead of the smaller column, converted it into a most valuable and powerful engine. The principle of the convertibility of the centres of oscillation and suspension in the pendulum, discovered by Huygens more than a century and a half ago, remained, until within these few years, a sterile, though most elegant proposition; when, after being hinted at by Prony, and distinctly pointed out by Bonenberger, it was employed by Captain Kater as the foundation of a most convenient method of determining the length of the pendulum. The interval which separated the discovery of Dr. Black, of latent heat, from the beautiful and successful application of it to the steam-engine, was comparatively short; but it required the efforts of two minds; and both were of the highest order." *

The discoveries of Davy present themselves in striking contrast with such instances. The same powerful genius that developed the laws of electro-chemical decomposition, was the first to apply them for the purpose of obviating metallic corrosion; and the nature of *fire-damp*, and the fact of its combustion being arrested in its passage through capillary tubes, were alike the discoveries of him who first applied them for the construction of a safety-lamp.†

In contrasting the genius of Wollaston with that of Davy, let me not be supposed to invite a comparison to the disparagement of either, but rather to

* " Reflections on the Decline of Science in England," page 15.

† While upon this subject, it is impossible not to notice the discoveries of Dr. Franklin, who combined in a remarkable degree a fertile imagination with a solid judgment; and the fruit of this union is to be seen in the invention of conductors for the security of ships and buildings against the effects of lightning. The philosopher who, predicating the identity of lightning and electricity, conceived the bold and grand idea of drawing it down from the thunder-cloud, an experiment which in another age would have consigned him to the dungeon for impiety, or to the stake for witchcraft, himself applied this wonderful discovery to the preservation of buildings, by the invention of pointed rods of iron. Of this invention it may be truly said, that he beat Nature with her own weapons, and triumphed over her power by an obedience to her own laws.

the glory of both, for by mutual reflection each will glow the brighter. If the animating principle of Davy's mind was a powerful imagination, generalizing phenomena, and casting them into new combinations, so may the striking characteristic of Wollaston's genius be said to have been an almost superhuman perception of minute detail. Davy was ever imagining something greater than he knew; Wollaston always knew something more than he acknowledged:—in Wollaston, the predominant principle was to avoid error; in Davy, it was the desire to discover truth. The tendency of Davy, on all occasions, was to raise probabilities into facts; while Wollaston as continually made them subservient to the expression of doubt.

Wollaston was deficient in imagination, and under no circumstances could he have become a Poet; nor was it to be expected that his investigations should have led him to any of those comprehensive generalizations which create new systems of philosophy. He well knew the compass of his powers, and he pursued the only method by which they could be rendered available in advancing knowledge. He was a giant in strength, but it was the strength of Antæus, mighty only on the earth. The extreme caution and reserve of his manner were inseparably connected with the habits of his mind; they pervaded every part of his character; in his amusements and in his scientific experiments, he displayed the same nice and punctilious observation,—whether he was angling for trout,* or testing for elements, he alike relied for success upon his subtile discrimination of minute circumstances.

By comparing the writings as well as the discoveries of these two great philosophers, we shall readily perceive the intellectual distinctions I have endeavoured to establish. "From their fruits shall ye know them." The discoveries of Davy were the results of extensive views and new analogies, those of Wollaston were derived from a more exact examination of minute and, to ordinary

* Sir Humphry Davy has told us an anecdote which well illustrates this observation, while it affords a gratifying testimony of the kind feeling he entertained towards a kindred philosopher.—"There was—alas! that I must say *there was*—an illustrious philosopher, who was nearly of the age of fifty before he made angling a pursuit, yet he became a distinguished fly-fisher, and the amusement occupied many of his leisure hours, during the last twelve years of his life. He, indeed, applied his pre-eminent acuteness, his science, and his philosophy, to aid the resources and exalt the pleasures of this amusement. I remember to have seen Dr. Wollaston, a few days after he had become a fly-fisher, carrying at his button-hole a piece of Indian rubber, when by passing his silk-worm link through a fissure in the middle, he rendered it straight, and fit for immediate use. Many other anglers will remember other ingenious devices of my admirable and ever-to-be-lamented friend."—*Salmonia. Additional Note*, Edit. 2.

observers, scarcely appreciable differences. This is happily illustrated by a comparison of the means by which each discovered new metals. The alkaline bases were the products of a comprehensive investigation, which had developed a new order of principles; the detection of palladium and rhodium among the ores of platinum, was the reward of delicate manipulation, and microscopic scrutiny. As chemical operators, I have already pointed out their striking peculiarities, and they will be found to be in strict keeping with the other features of their respective characters. I might extend the parallel farther; but Dr. Henry, in the eleventh edition of his System of Chemistry, has delineated the intellectual portraits of these two philosophers with so masterly a hand, that by quoting the passage, all farther observation will be rendered unnecessary.

"To those high gifts of nature, which are the characteristics of genius, and which constitute its very essence, both those eminent men united an unwearied industry and zeal in research, and habits of accurate reasoning, without which even the energies of genius are inadequate to the achievement of great scientific designs. With these excellencies, common to both, they were nevertheless distinguishable by marked intellectual peculiarities. Bold, ardent, and enthusiastic, Davy soared to greater heights; he commanded a wider horizon; and his keen vision penetrated to its utmost boundaries. His imagination, in the highest degree fertile and inventive, took a rapid and extensive range in pursuit of conjectural analogies, which he submitted to close and patient comparison with known facts, and tried by an appeal to ingenious and conclusive experiments. He was imbued with the spirit, and was a master in the practice, of the inductive logic; and he has left us some of the noblest examples of the efficacy of that great instrument of human reason in the discovery of truth. He applied it, not only to connect classes of facts of more limited extent and importance, but to develope great and comprehensive laws, which embrace phenomena that are almost universal to the natural world. In explaining those laws, he cast upon them the illumination of his own clear and vivid conceptions; — he felt an intense admiration of the beauty, order, and harmony, which are conspicuous in the perfect Chemistry of Nature;—and he expressed those feelings with a force of eloquence, which could issue only from a mind of the highest powers, and of the finest sensibilities. With much less enthusiasm from temperament, Dr. Wollaston was endowed with bodily senses* of extraordinary acuteness and accuracy,

* Mr. Babbage considers it as a great mistake to suppose that Dr. Wollaston's microscopic accuracy depended upon the extraordinary acuteness of the bodily senses; a circumstance, he says,

and with great general vigour of understanding. Trained in the discipline of the exact sciences, he had acquired a powerful command over his attention, and had habituated himself to the most rigid correctness, both of thought and of language. He was sufficiently provided with the resources of the mathematics, to be enabled to pursue, with success, profound enquiries in mechanical and optical philosophy, the results of which enabled him to unfold the causes of phenomena not before understood, and to enrich the arts connected with those sciences, by the invention of ingenious and valuable instruments. In Chemistry, he was distinguished by the extreme nicety and delicacy of his observations; by the quickness and precision with which he marked resemblances and discriminated differences; the sagacity with which he devised experiments and anticipated their results; and the skill with which he executed the analysis of fragments of new substances, often so minute as to be scarcely perceptible by ordinary eyes. He was remarkable, too, for the caution with which he advanced from facts to general conclusions; a caution which, if it sometimes prevented him from reaching at once to the most sublime truths, yet rendered every step of his ascent a secure station, from which it was easy to rise to higher and more enlarged inductions. Thus these illustrious men, though differing essentially in their natural powers and acquired habits, and moving, independently of each other, in different paths, contributed to accomplish the same great ends—the evolving new elements; the combining matter into new forms; the increase of human happiness by the improvement of the arts of civilized life; and the establishment of general laws, that will serve to guide other philosophers onwards, through vast and unexplored regions of scientific discovery."

My history draws towards a conclusion.—Sir Humphry Davy, during the latter days of his life, was cheered by the society and affectionate attentions of his godson, the son of his old friend Mr. James Tobin.* He had been the companion of his travels, and he was the solace of his declining hours.

He had been resident for some months at Rome, where he occupied the second floor of a house in Via di Pietra, a street that leads out of the Corso.

which, if it were true, would add but little to his philosophical character. He is inclined to view it in a far different light, and to see in it one of the natural results of the precision of his knowledge, and of the admirable training of his intellectual faculties.

* This inestimable man died on his plantation at Nevis, on the 19th of October 1814, in the forty-eighth year of his age.

During this period, he declined receiving any visitors, and had constantly some one by his side reading light works of interest to him, an amusement which was even continued during his meals.

As soon as the account of Sir Humphry having sustained another paralytic seizure was communicated to Lady Davy, who was in London at the time, she immediately set off, and so rapidly was her journey performed, that she reached Rome in little more than twelve days. Dr. John Davy, also, hastened from Malta, on receiving intelligence of his brother's imminent danger.

During his slow and partial recovery from this seizure, he learnt the circumstance of his name having been introduced into parliamentary proceedings, in the following manner. On the 26th of March 1829, on presenting a petition in favour of the Catholic claims from a very great and most respectable meeting at Edinburgh, Sir James Mackintosh, after having mentioned the name of Sir Walter Scott as being at the head of the petitioners, continued thus:—"Although not pertinent to this petition, yet connected with the cause, I indulge in the melancholy pleasure of adding to the first name in British literature the first name in British science—that of Sir Humphry Davy. Though on a sick bed at Rome, he was not so absorbed by his sufferings as not to feel and express the glow of joy that shot across his heart at the glad tidings of the introduction of a bill which he hailed as alike honourable to his religion and his country."

I am assured that the last mark of satisfaction which he evinced from any intelligence communicated to him was on reading the above passage. He showed a pleasure unusual in his state of languor at the justice thus done, in the face of his country, to his consistency, to his zeal for religion and liberty, and to the generous sentiments which cheered his debility. The marks of his pleasure were observed by those who were brought most near to him by the performance of every kind office.

Although there appeared some faint indications of reviving power, his most sanguine friends scarcely ventured to indulge a hope that his life would be much longer protracted. Nor did he himself expect it. The expressions in his Will (printed in an Appendix,) sufficiently testify the opinion he had for some time entertained of the hopelessness of his case.

In addition to this Will, he left a paper of directions, which have been religiously observed by his widow. He desires, for instance, that the interest arising from a hundred pounds stock may be annually paid to the Master of the Penzance Grammar School, on condition that the boys may have a holiday on his birth-day.* There is something singularly interesting in this favourable recollection of his native town, and of the associations of his early youth. It adds one more example to show that, whatever may have been our destinies, and however fortune may have changed our conditions, where the heart remains uncorrupted, we shall, as the world closes upon us, fix our imaginations upon the simplicities of our youth, and be cheered and warmed by the remembrance of early pleasures, hallowed by feelings of regard for the memory of those who have long since slept in the grave.

With that restlessness which characterises the disease under which Sir Humphry Davy suffered, he became extremely desirous of quitting Rome, and of establishing himself at Geneva. His friends were naturally anxious to gratify every wish; and Lady Davy therefore preceded him on the journey, in order that she might prepare for his comfortable reception at that place. Apartments were accordingly in readiness for him at *L'Hotel de la Couronne*, in the Rue du Rhone; and at three o'clock on the 28th of May, having slept the preceding evening at Chambery, he arrived at Geneva, accompanied by his brother, Mr. Tobin, and his servant.

At four o'clock he dined, ate heartily, was unusually cheerful, and joked with the waiter about the cookery of the fish, which he appeared particularly to admire; and he desired that, as long as he remained at the hotel, he might be daily supplied with every possible variety that the lake afforded. He drank tea at eleven, and having directed that the feather-bed should be removed, retired to rest at twelve.

His servant, who slept in a bed parallel to his own, in the same alcove, was however very shortly called to attend him, and he desired that his brother might be summoned. I am informed that, on Dr. Davy's entering the room, he said, "I am dying," or words to that effect; "and when it is all over, I desire that no disturbance of any kind may be made in the house; lock the door, and let every one retire quietly to his apartment." He expired at a quarter before three o'clock without a struggle.

On the following morning, his friends Sismondi † and De Candolle were sent for; and the Syndics, as soon as the circumstance of his death was communicated to them, gave directions for a public funeral on the Monday; at

* I understand that the present Master, the Reverend Mr. Morris, has expressed his intention to apply the above sum to purchasing a medal, which he intends to bestow as a Prize to the most meritorious scholar.

† Simond de Sismondi, the celebrated author of the History of the Italian Republic.

which, the magistrates, the professors, the English residents at Geneva, and such inhabitants as desired it, were invited to attend. The ceremony was ordered to be conducted after the custom of Geneva, which is always on foot —no hearse; nor did a single carriage attend. The cemetery is at Plain-Palais, some little distance out of the walls of the town. The Couronne being at the opposite extremity, the procession was long.

The following was the order of the procession:—*

The Two Syndics, (*in their robes*) { M. Mastow, M. Gallatin.

Magistrates of the Republic, { M. Fazio, M. Salladin.

Professors of the College, in their robes,
MM. Simond de Sismondi—A. de Candolle.

THE ENGLISH.

Lord Eglington,	Captain Archibald Hamilton,
Lord Twedell,	Mr. Campbell,
The Right Hon. Wm. Wyckham,	Mr. Franks,
Wm. Hamilton, Esq., Ex-Ambassador at Naples,	Mr. Alcock,
	Mr. Drew,
Sir Egerton Brydges, Bart.	Mr. Heywood,
Colonel Alcock,	Mr. Sitwell,
Captain Swinters,	&c.

The Students of the College.
The Citizens of Geneva.

The English service was performed by the Rev. John Magers, of Queen's College, and the Rev. Mr. Burgess.

The grave was stated in the public prints to be next to that of his friend, the late Professor M. A. Pictet; this is not the fact. It is far away from it, on the second line of No. 29, the fourth grave from the end of the west side of the Cemetery.

Sir Humphry Davy having died without issue, his baronetcy has become extinct.

* For these particulars, I am indebted to Sir Egerton Brydges.

At present, the only memorial raised to commemorate the name of this distinguished philosopher is, a Tablet placed in Westminster Abbey by his widow. It is thus inscribed:—

TO THE MEMORY OF
SIR HUMPHRY DAVY, BARONET;
DISTINGUISHED THROUGHOUT THE WORLD
BY HIS
DISCOVERIES IN CHEMICAL SCIENCE.
PRESIDENT OF THE ROYAL SOCIETY;
MEMBER OF THE NATIONAL INSTITUTE OF FRANCE.
BORN 17 DECEMBER 1778, AT PENZANCE.
DIED 28 MAY 1829, AT GENEVA,
WHERE HIS REMAINS ARE INTERRED.

The numerous scientific societies of which he was a member, will, no doubt, consecrate his memory. An eloquent Eloge has been read by Baron Cuvier before the Institute of France; but it has not yet been published: I have obtained, however, a copy of a speech delivered upon the same occasion, by H. C. Van der Boon Mesch, before the Institute of the Netherlands.

Mr. Davies Gilbert, his early friend and patron, has likewise paid to his memory a just and appropriate testimony of respect and admiration, in an address from the chair of the Royal Society.

The inhabitants of Penzance and its neighbourhood, animated by feelings of honourable pride and strong local attachment, will shortly, it is understood, raise a pyramid of massive granite to his memory, on one of those elevated spots of silence and solitude, where he delighted in his boyish days to commune with the elements, and where the Spirit of Nature moulded his genius in one of her wildest moods.

As yet, no intention on the part of the Government to commemorate this great philosopher, by the erection of a national monument, has been manifested; for the credit, however, of an age which is so continually distinguished as the most enlightened period in our history, I do hope the disgrace of such an omission may pass from us; although, I confess, it is rather to be wished than expected, when it is remembered that not a niche has been graced by the statue of Watt, while the giant iron children of his inventive genius are serving mankind in every quarter of the civilized world. A very erroneous impression would seem to exist with regard to the object and importance of such monuments. They are not to honour the dead, but to improve the living; not to give lustre to the philosopher, but to afford a salutary incentive to the disciple; not to perpetuate discoveries, for they can never be lost; but to animate scientific genius, and to engage it upon objects that may be useful to the commonwealth. Let it be remembered, that the ardour of the Roman youth was kindled into active emulation, whenever they beheld the images of their ancestors.

"Nam sæpe audivi, Q. Maximum, P. Scipionem, præterea civitatis nostræ præclaros viros, solitos ita dicere, cùm majorum imagines intuerentur, vehementissimè sibi animum ad virtutem accendi. Scilicet non ceram illam, neque figuram tantam vim in sese habere; sed memoriâ rerum gestarum eam flammam egregiis viris in pectore crescere, neque prius sedari, quàm virtus eorum famam atque gloriam adæquaverit."*

The fame of such a philosopher as Davy can never be exalted by any frail memorial which man can raise. His monument is in the great Temple of Nature.† His chroniclers are Time and the Elements. The destructive agents which reduce to dust the storied urn, the marble statue, and the towering pyramid, were the ministers of his power, and their work of decomposition is a perpetual memorial of his intelligence.

* Sallust. Bell. Jugurth.

† Ἀνδρῶν γὰρ ἐπιφανῶν πᾶσα γῆ τάφος, καὶ οὐ στηλῶν μόνον ἐν τῇ οἰκείᾳ σημαίνει ἐπιγραφὴ, ἀλλὰ καὶ ἐν τῇ μὴ προσηκούσῃ ἄγραφος μνήμη παρ' ἑκάστῳ τῆς γνώμης μᾶλλον ἢ τοῦ ἔργου ἐνδιαιτᾶται.

Thucydides, B. 43.

A SKETCH OF THE HISTORY OF CHEMICAL SCIENCE, WITH A VIEW TO EXHIBIT THE REVOLUTIONS PRODUCED IN ITS DOCTRINES BY THE DISCOVERIES OF SIR HUMPHRY DAVY.

The rapidity with which chemical opinions have risen into notice, flourished for a while, and then fallen into disrepute, to be succeeded by others equally precarious in their tenure and ephemeral in their popularity, are circumstances which the superficial reasoner has ever deplored, and the Sciolist as constantly converted into arguments against the soundness of the science which produced them. The leaves of a season will sprout, expand, and wither; and the dry foliage will be pushed off by the propulsion of new buds; but this last change is not effected in them, until they have absorbed the light and dews of heaven for the nourishment of the plant that bore them; and when even they shall have fallen to the earth, they will farther supply its spreading roots with fresh soil for its future growth and healthy developement; and entering into new combinations, will re-appear in the same tree under fresh forms of usefulness and symmetry. In like manner, chemical theories are but for a season; they are nothing more than general expressions of known facts; they may delight by their ingenuity, as vegetable forms captivate by their beauty, but their real and substantial use is to extend science; and as facts accumulate under their operation, they must give way to others better adapted to the increased growth and expansion of knowledge: nor does the utility of theories cease with their rejection,—they afford objects of analogy and comparison which assist the philosopher in his progress to truth, while their elements furnish materials for future arrangements. Were it otherwise, we should behold science in its advancement as a shapeless mass, enlarging by constant appositions, but without a single sign of growth or inward sympathy.

If chemical theories have undergone more rapid and frequent changes than those of other branches, the circumstance has arisen from the rapid manner in which new and important facts have been successively added to the general store.

Whatever may be the vices attributed to Chemistry on such occasions, they have belonged to the philosophers engaged in its pursuit, and are no evidence of the frailty of the science itself; and here it must be admitted, that there exists in one portion of mankind a self-love which cannot patiently submit to a change of opinions of which they are either the authors or defenders, while in another there predominates a timidity which naturally leads them, amidst the storm of controversy, to cling to the wreck of a shattered theory, rather than to trust themselves to a new and untried bark.

In our review of the history of science, we have frequently to witness how the wisest philosopher has strained truth, for the support of a favourite doctrine, and measured and accommodated facts to theory, instead of adapting theories to facts—but this vice does not belong exclusively to chemical philosophers. Huygens, the celebrated Dutch Astronomer, from some imaginary property in the number *six*, having discovered *one* of Saturn's moons, absolutely declined looking for any more, merely because that one, when added to the four moons of Jupiter, and to the one belonging to the earth, made up the required number.

Such reflections naturally arise on viewing, with a philosophic eye, the progress and modifications of chemical opinions; and it is essential that they should be duly appreciated upon the present occasion; for, before any just estimate can be formed of the talents and services of Sir Humphry Davy, we must thoroughly consider, in all their bearings and relations, the various prejudices with which he had to contend in his efforts to modify a gigantic theory, which enjoyed an unrestrained dominion in the chemical world, and for many years continued to be the pride of France, and the admiration of Europe.

It would be quite foreign to the plan of this sketch,* which the reader must consider as wholly subservient to the object that has been announced, to enquire how far the ancients, in their metallurgical processes, can be said to have exercised the arts of chemistry. Equally vain would it be to enter into a history of that system of delusion and imposture, so long practised under the denomination of Alchymy. It is only necessary to consider Chemistry in its dignified and purely scientific form; and we have only to notice those commanding discoveries and opinions which led to the developement of that system, which the genius of Davy was destined to modify.

The origin of Chemistry, as a science, cannot be dated farther back than about the middle of the seventeenth century; and Becher, the contemporary of Boyle, who was born at Spires in 1635, was unquestionably the first to con-

* This historical sketch has no pretensions to originality. It is compiled from the best authors, and from the Introduction to Sir H. Davy's Elements of Chemical Philosophy.

struct any thing like a general theory. He formed the bold idea of explaining the whole system of the earth by the mutual agency and changes of a few elements. And by supposing the existence of a vitrifiable, a metallic, and an inflammable earth, he attempted to account for the various productions of rocks, crystalline bodies, and metallic veins, assuming a continual interchange of principles between the atmosphere, the ocean, and the solid surface of the globe, and considering the operations of nature as all capable of being imitated by art.

Albertus Magnus had advanced the opinion that the metals were earthy substances impregnated with a certain inflammable principle; but Beccher supported the idea of this principle not only as the cause of metallization, but likewise of combustibility. Stahl, however, one of the most extraordinary men that Germany ever produced, having adopted and amplified this theory, carried off the entire credit of being its founder, and it is universally spoken of as the *Stahlian Theory*.

This theory forms so important a feature in the history of chemistry, and so long maintained its ascendency in the schools, that it will be necessary to give the reader a short summary of its principles. It assumed that all *combustible* bodies are compounds: one of the constituents being volatile, and therefore easily dissipated during the act of combustion; while the other, being fixed, constantly remained as the residue of the process. This volatile principle, for which Stahl invented the term *Phlogiston*, was considered as being identical in every species of combustible matter; in short, it was supposed that there was but one principle of combustibility in nature, and that was the imaginary phantom Phlogiston, which for nearly a century possessed the schools of Europe, and, like an evil spirit, crossed the path of the philosopher at every step, and by its treacherous glare allured him from the steady pursuit of truth; for, whether a substance were combustible or not, its nature could never be investigated without a reference to its supposed relations with Phlogiston; its presence, or its absence, was supposed to stamp a character upon all bodies, and to occasion all the changes which they undergo. Hence chemistry and combustion came to be in some measure identified; and a theory of combustion was considered the same thing as a theory of chemistry.

The identity of Phlogiston in all combustible bodies was founded upon observations and experiments of so decisive a nature, that after the existence of the principle itself was admitted, they could not fail to be satisfactory. When phosphorus is made to burn, it gives out a strong flame, much heat is evolved, and the phosphorus is dissipated in fumes, which, if properly collected, will quickly absorb moisture from the atmosphere, and produce an acid liquid known by the name of phosphoric acid. Phosphorus then must consist, say the Stahlians, of Phlogiston and this acid. Again—If this liquid be evaporated to a dry substance, mixed with a quantity of charcoal powder, and then heated in a vessel from which the external air is excluded, a *portion*, or the *whole* of the charcoal will disappear, and phosphorus will be reproduced, possessing all the properties that it had before it was subjected to combustion. In this case, it was supposed that the charcoal restored the phlogiston. There was much plausibility in all this, as well as in the reasoning which followed. Since we may employ, with equal success, any kind of combustible body for the purpose of changing phosphoric acid into phosphorus, such as lamp-black, sugar, resin, or even several of the metals, it was concluded that all such bodies contain a common principle which they communicate to the phosphoric acid; and since the new body formed is in all cases identical, the principle communicated must also be identical. Hence combustible bodies contain an identical principle, and this principle is Phlogiston.

The same theory applied with equal force to the burning of sulphur and several of the metals, and to their reconversion by combustible bodies.

When lead is kept nearly at a red-heat in the open air for some time, it is converted into a pigment called *red lead;* this is a calx of lead. To restore this calx again to metallic lead, it is only necessary to heat it in contact with almost any combustible matter; all these bodies therefore must contain one common principle, which they communicated to the red lead, and by so doing reconverted it to the state of metal. Metals then were regarded as compounds of *calces* and phlogiston. Thus far the theory works glibly enough; but now comes a startling fact, which was long unnoticed by the blind adherents of Stahl, or, if noticed, intentionally overlooked. It was observed very early, that when a metal was converted into a calx, its weight was increased. When this difficulty first forced itself upon the attention of the Phlogistians, it was necessary that they should either explain it, or at once abandon their theory. They accordingly endeavoured to evade the difficulty, not only by asserting that phlogiston had no weight, but that it was actually endowed with a principle of levity.

It was not possible, however, that any rational notions should have been entertained upon the subject of combustion, at a period when the composition of the atmosphere even was unknown. Let us therefore follow the stream of discovery, skimming the surface merely, as it flowed onward towards quite a new field of science—Pneumatic Chemistry.

Boyle and Hooke, who had improved the air-pump invented by Otto de

Guericke, of Madenburgh, first used this apparatus for investigating the properties of air; and they concluded from their experiments that air was absolutely necessary to combustion and respiration, and that one part of it only was employed in these processes; and Hooke formed the sagacious conclusion, that this principle is the same as the substance fixed in nitre, and that combustion is a chemical process, the solution of the burning body in elastic fluid, or its union with this matter.

Mayow of Oxford, in 1674, published his treatises on the Nitro-aërial spirit, in which he advanced opinions similar to those of Boyle and Hooke, and supported them by a number of original and curious experiments.

Dr. Hales, about 1724, resumed the investigations commenced with so much success by Boyle, Hooke, and Mayow; and endeavoured to ascertain the chemical relations of air to other substances, and to ascertain by statistical experiments the cases in nature, in which it is absorbed or emitted. He obtained a number of curious and important results; he disengaged elastic fluids from various substances, and drew the conclusion, that air was a chemical element in many compound bodies, and that flame resulted from the action and reaction of aërial and sulphurous particles; but all his reasonings were contaminated with the notion of one elementary principle constituting elastic matter, and modified in its properties by the effluvia of solid or fluid bodies.

The light of Pneumatic science which had dawned under Hooke, Mayow, and Hales, burst forth in splendour under the ascendency of that constellation of British science, Black, Cavendish, and Priestley.

In 1756, Dr. Black published his researches on calcareous, magnesian, and alkaline substances, by which he proved the existence of a gaseous body, perfectly distinct from the air of the atmosphere. He showed, that quick-lime differed from marble and chalk by not containing this substance, which he proved to be a weak acid, capable of being expelled from alkaline and earthy bodies by stronger acids.

As nothing is more instructive than to enquire into the circumstances which have led to a great discovery, I quote with pleasure the following passage from Dr. Thomson's History of Chemistry.

" It was the good fortune of chemical science that, at this time (1751), the opinions of professors were divided concerning the manner in which certain lithonthriptic medicines, particularly lime-water, acted in alleviating the excruciating pains of the stone and gravel. The students usually partake of such differences of opinion: they are thereby animated to more serious study, and science gains by their emulation.

" All the medicines which were then in vogue as solvents of calculi had a greater or less resemblance to caustic potash or soda; substances so acrid, when in a concentrated state, that in a short time they reduce the fleshy parts of the animal body to a mere pulp. They all seemed to derive their efficacy from quick-lime, which again derived its power from the fire. It was therefore very natural for them to ascribe its power to igneous matter imbibed from the fire, retained by the lime, and communicated by it to alkalies which it renders powerfully acrid. It appears from Dr. Black's note-books, that he originally entertained the opinion, that caustic alkalies acquired igneous matter from quick-lime. In one of them, he hints at some way of catching this matter as it escapes from lime, while it becomes mild by exposure to the air; but on the opposite blank page is written, ' Nothing escapes—the cup rises considerably by absorbing air.' A few pages further on, he compares the loss of weight sustained by an ounce of chalk when calcined, with its loss while dissolved in muriatic acid.

" These experiments laid open the whole mystery, as appears by another memorandum. ' When I precipitate lime by a common alkali, there is no effervescence: the air quits the alkali for the lime; but it is lime no longer, but C. C. C: it now effervesces, which good lime will not.'—What a multitude of important consequences naturally flowed from this discovery! He now knew to what the causticity of alkalies is owing, and how to induce it, or remove it, at pleasure. The common notion was entirely reversed. Lime imparts nothing to the alkalies; it only removes from them a peculiar kind of air *(carbonic acid gas)* with which they were combined, and which prevented their natural caustic properties from being developed. All the former mysteries disappear, and the greatest simplicity appears in those operations of nature which before appeared so intricate and obscure."

Dr. Thomson afterwards observes, — " The discovery which Dr. Black had made that marble is a combination of lime and a peculiar substance, to which he gave the name of *fixed air*, began gradually to attract the attention of chemists in other parts of the world. It was natural, in the first place, to examine the nature and properties of this fixed air, and the circumstances under which it is generated. It may seem strange and unaccountable that Dr. Black did not enter with ardour into this new career which he had himself opened, and that he allowed others to reap the corn after having himself sown the grain. Yet he did take some steps towards ascertaining the properties of *fixed air;* though I am not certain what progress he made. He knew that a candle would not burn in it, and that it is destructive to life, when any living animal attempts to breathe it. He knew that it is formed in the lungs during the breathing of animals, and that it is generated during the fermentation of wine and beer. Whether he was aware that it possesses the properties of an acid, I do not know; though with the knowledge which he possessed that it combines with alkalies and alkaline earths, and neutralizes them, or at least blunts and diminishes their alkaline properties, the conclusion that it partook of acid properties was scarcely avoidable. All these, and probably some other properties of *fixed air*, he was in the constant habit of stating in his lectures from the very commencement of his academical career; though, as he never published any thing on the subject himself, it is not possible to know exactly how far his knowledge of the properties of *fixed air* extended. The oldest manuscript copy of his lectures that I have seen was taken down in writing in the year 1773; and before that time Mr. Cavendish had published his paper on *fixed air* and *hydrogen gas*, and had detailed the properties of each. It was impossible from the manuscript of Dr. Black's lectures, to know which of the properties of *fixed air* stated by him were discovered by himself, and which were taken from Mr. Cavendish."

An idea so novel and important as that of an air possessing properties quite different from that of the atmosphere, existing in a fixed and solid state in various bodies, was not received without doubt, and even opposition. Several German enquirers endeavoured to controvert it. Meyer attempted to show that limestone became caustic, not by the emission of elastic matter, but by combining with a peculiar substance in the fire; the loss of weight, however, was wholly inconsistent with such a view of the question: and Bergman at Upsal, Macbride in Ireland, Keir at Birmingham, and Cavendish in London, fully demonstrated the truth of the opinion of Black, and a few years were sufficient to establish his theory upon an immutable foundation, and to open a new road to most important discoveries.

The knowledge of one elastic fluid, entirely different in its properties from air, very naturally suggested the probability of the existence of others. The processes of fermentation which had been observed by the ancient chemists, and those by which Hales had disengaged and collected elastic substances, were now regarded under a novel point of view; and the consequence was, that a number of new bodies possessed of very extraordinary properties, were discovered.

Mr. Cavendish, about the year 1765, invented an apparatus for examining elastic fluids confined by water, which has since been called the *hydro-pneumatic* apparatus. He discovered inflammable air, and described its properties;

he ascertained the relative weights of fixed air, inflammable air, and common air, and made a number of beautiful and accurate experiments on the properties of these elastic substances.

Dr. Priestley, in 1771, entered the same path of enquiry; and principally by repeating the processes of Hales, added a number of most important facts to this department of chemical philosophy. He discovered nitrous air, nitrous oxide, and dephlogisticated air, (oxygen) and by substituting mercury for water in the pneumatic apparatus, ascertained the existence of several aëriform bodies which are rapidly absorbable by water; such as muriatic acid gas, sulphurous acid gas, and ammonia.

Scheele, independently of Priestley, also discovered several of the aëriform bodies; he ascertained likewise the composition of the atmosphere; he brought to light fluoric acid, prussic acid, and the substance which he termed *dephlogisticated marine acid*, the oxymuriatic acid of the French school, and the chlorine of Davy.

Sir Humphry Davy, in the preface to his Chemical Philosophy, observes that Black, Cavendish, Priestley, and Scheele, were undoubtedly the greatest chemical discoverers of the eighteenth century; and that their merits are distinct, peculiar, and of the most exalted kind. He thus defines them:

" Black made a smaller number of original experiments than either of the other philosophers; but being the first labourer in this new department of the science, he had greater difficulties to overcome. His methods are distinguished for their simplicity, his reasonings are admirable for their precision; and his modest, clear, and unaffected manner is well calculated to impress upon the mind a conviction of the accuracy of his processes, and the truth and candour of his researches.

" Cavendish was possessed of a minute knowledge of most of the departments of Natural Philosophy: he carried into his chemical researches a delicacy and precision, which have never been exceeded: possessing depth and extent of mathematical knowledge, he reasoned with the caution of a geometer upon the results of his experiments; and it may be said of him, what, perhaps, can scarcely be said of any other person, that whatever he accomplished, was perfect at the moment of its production. His processes were all of a finished nature; executed by the hand of a master, they required no correction; the accuracy and beauty of his earliest labours even have remained unimpaired amidst the progress of discovery, and their merits have been illustrated by discussion and exalted by time.

" Dr. Priestley began his career of discovery without any general knowledge of chemistry, and with a very imperfect apparatus. His characteristics were ardent zeal and the most unwearied industry. He exposed all the substances he could procure to chemical agencies, and brought forward his results as they occurred, without attempting logical method or scientific arrangement. His hypotheses were usually founded upon a few loose analogies; but he changed them with facility; and being framed without much effort, they were relinquished with little regret. He possessed in the highest degree ingenuousness and the love of truth. His manipulations, though never very refined, were always simple, and often ingenious. Chemistry owes to him some of her most important instruments of research, and many of her most useful combinations; and no single person ever discovered so many new and curious substances.

"Scheele possessed in the highest degree the faculty of invention; all his labours were instituted with an object in view, and after happy or bold analogies. He owed little to fortune or to accidental circumstances: born in an obscure situation, occupied in the duties of an irksome employment, nothing could damp the ardour of his mind, or chill the fire of his genius; with very small means, he accomplished very great things. No difficulties deterred him from submitting his ideas to the test of experiment. Occasionally misled in his views, in consequence of the imperfection of his apparatus, or the infant state of the enquiry, he never hesitated to give up his opinions the moment they were contradicted by facts. He was eminently endowed with that candour which is characteristic of great minds, and which induces them to rejoice as well in the detection of their own errors, as in the discovery of truth. His papers are admirable models of the manner in which experimental research ought to be pursued; and they contain details on some of the most important and brilliant phenomena of chemical philosophy."

The discovery of the gases, of a new class of bodies more active than any others in most of the phenomena of nature and art, could not fail to modify the whole theory of chemistry, and, under the genius of Lavoisier, it ultimately led to the establishment of those new doctrines, which it is the principal object of this history to expound; but before this task can be accomplished, it will be necessary to consider the rise and progress of opinion concerning chemical attraction, and heat and light, since these subjects are too intimately interwoven with the *anti-phlogistic* system to be separated from any examination of its principles.

Boyle, says Sir Humphry Davy, was one of the most active experimenters, and certainly the greatest chemist of his age. He introduced the use of *tests*, or *re-agents*, active substances for detecting the presence of other bodies: he overturned the ideas which at that time were prevalent, that the results of operations by fire were the real elements of things; and he ascertained a number of important facts respecting inflammable bodies, and alkalies, and the phenomena of combination; but neither he nor any of his contemporaries endeavoured to account for the changes of bodies by any fixed principles.

The solutions of the phenomena were attempted either on rude mechanical notions, or by occult qualities, or peculiar subtile spirits or ethers, supposed to exist in the different bodies. And it is to the same great genius who developed the laws that regulate the motions of the heavenly bodies, that chemistry owes the first distinct philosophical elucidations of the powers which produce the changes and apparent transmutations of the substances belonging to the earth.

"Sugar dissolves in water, alkalies unite with acids, metals dissolve in acids. Is not this," says Newton, "on account of an attraction between their particles? Copper dissolved in aqua fortis is thrown down by iron. Is not this because the particles of the iron have a stronger attraction for the particles of the acid, than those of copper; and do not different bodies attract each other with different degrees of force?"

In 1719, Geoffroy endeavoured to ascertain the relative attractive powers of bodies for each other, and to arrange them, under the form of a table, in an order in which these forces, which he named affinities, were expressed.

Concerning the nature of heat, there are two opinions which have ever divided the chemical world. The one considers it merely as a property of matter, and that it consists in an undefinable motion, or vibration of its particles; the other, on the contrary, regards it as a distinct and subtile substance, *sui generis*. Each of these opinions has been supported by the greatest philosophers, and for a long period the arguments on both sides appeared equally plausible and forcible. The discovery of Dr. Black, however, gave a preponderance to the scale in favour of its materiality.

"It was during his residence in Glasgow, between the years 1759 and 1763," says Dr. Thomson, "that he brought to maturity those speculations concerning the combination of *heat* with *matter*, which had frequently occupied a portion of his thoughts."

Before Dr. Black's discovery, it was universally supposed that solids were converted into liquids by a small addition of heat, after they have been once raised to the melting point, and that they returned again to the solid state on a very small diminution of the quantity of heat necessary to keep them at that temperature. An attentive view, however, of the phenomena of liquefaction and solidification gradually led this sagacious philosopher to a different conclusion. By observations which it is unnecessary to detail, he became satisfied that when ice is converted into water, it unites with a quantity of heat, without having its temperature increased; and that when water is frozen into ice, it gives out a quantity of heat without having it diminished. The heat thus combined, then, is the cause of the fluidity of the water; and as it is not sensible to the thermometer, Dr. Black called it *latent heat.*

There is such an analogy between the cessation of thermometric expansion during the liquefaction of ice, and during the conversion of water into steam, that there could be no hesitation about explaining both in the same way. Dr. Black, therefore, immediately concluded that, as water is ice united to a certain quantity of *latent* heat, so steam is water united to a still greater quantity.

This beautiful theory enables us to understand phenomena in nature which were previously quite inexplicable. We now comprehend how the thaw which supervenes after intense frost, should so slowly melt the wreaths of snow and beds of ice. Had, indeed, the transition of water from its solid into its liquid state not been accompanied by this great change in its relation to heat, every thaw would have occasioned a frightful inundation, and a single night's frost must have solidified our rivers and lakes. Neither animal nor vegetable life could have subsisted under such sudden and violent transitions. It would appear, then, that water, during the act of freezing, is acted upon by two opposite powers: it is deprived of heat by exposure to a medium whose temperature is below 32°; and it is supplied with heat by the evolution of that principle from itself, *viz.* of that portion which constituted its fluidity. As these powers are exactly equal, the temperature of the water must remain unchanged till the latent heat, necessary to its fluidity, is all evolved.

Although these facts have been admitted by all, it has been contended by many that the absorption of heat by bodies is the necessary *effect* and not the efficient *cause* of change of form,—the consequence of what has been called a change of their *capacity:* thus ice, it is supposed, in becoming water, has its capacity for heat increased, and the absorption of heat is a consequence of such increased capacity. This theory, however, is deficient, in as much as it fails to explain the cause of that change of form, which is assumed to account for the increase of capacity.

Light, like heat, has been considered by some philosophers as a subtile fluid filling space, and rendering bodies visible by the undulations into which it is thrown; while others, with Newton at their head, regard it as a substance consisting of small particles, constantly separating from luminous bodies, moving in straight lines, and rendering objects visible by passing from them and entering the eye. The late experiments of Dr. Young would incline us to prefer the undulatory to the corpuscular hypothesis.

By this preliminary sketch, the reader has been prepared for viewing with advantage the theory of Lavoisier; in the construction of which he will see little more than a happy generalization of the several discoveries which have been enumerated: indeed, this observation will apply to all great systems of philosophy; facts, developed by successive enquirers, go on accumulating, until, after an interval, a happy genius arises who connects and links them together; and thus generally receives that meed of praise which, in stricter justice, would be apportioned and awarded to the separate contributors. It is far from my intention to disparage the merits of Lavoisier; but the materials of his system were undoubtedly furnished by Black, Priestley, and Cavendish.

The most important modification of the phlogistic theory,—for there were several others,—may be said to be that suggested by Dr. Crawford. Dr. Priestley had found that the air in which combustibles were suffered to burn till they were extinguished, underwent a very remarkable change, for no combustible would afterwards burn in it, and no animal could breathe it without suffocation. Dr. Crawford, like many others, concluded, that this change was owing to phlogiston; but he for the first time applied Dr. Black's doctrine of *latent* heat, for the explanation of the origin of the heat and light which appear during the process. According to this philosopher, the phlogiston of the combustible combines, during combustion, with the air, and at the same time separates the caloric and light with which that fluid had been previously united. The heat and the light, then, which appear during combustion, exist previously in the air. This theory was very different from Stahl's, and certainly a great deal more satisfactory; but still the question—*What is phlogiston?* remained to be answered.

Mr. Kirwan attempted to answer it, and to prove that phlogiston is no other than hydrogen.

This opinion, which Mr. Kirwan informs us was first suggested by the discoveries of Dr. Priestley, met with a very favourable reception from the chemical world, and was adopted, amongst many others, by Mr. Cavendish. The object of Mr. Kirwan was to prove, that hydrogen exists as a component part of every combustible body; that during combustion, it separates from the combustible body, and combines with the oxygen of the air. At the same time, Lavoisier was engaged in examining the experiment of Bayen, and those of the British philosophers. Bayen, in 1774, had shown that mercury converted into a calx, or earth, by the absorption of air, could be revived without the addition of any inflammable substance; and hence he concluded, that there was no necessity for supposing the existence of any peculiar principle of inflammability, in order to account for the calcination of metals; but he formed no opinion respecting the nature of the air produced from the *calx* of mercury. Lavoisier, in 1775, showed that it was an air, which supported flame and respiration better than common air, which he afterwards named oxygen; the same substance that Priestley and Scheele had procured from other metallic bodies the year before, and had particularly described.

Lavoisier also discovered that the same air is produced during the revivification of metallic calces by charcoal, as that which is emitted during the calcination of limestones; hence he concluded, that this elastic fluid is composed of oxygen and charcoal: and from his experiments on nitrous acid and oil of vitriol, he also inferred that this gas entered into the composition of these substances.

Lavoisier was now enabled to explain the phenomena of combustion, without having recourse to phlogiston; a principle merely supposed to exist, because combustion could not be explained without it.

His new theory depends upon the two laws discovered by himself and Dr. Black, *viz.* that when a combustible is raised to a certain temperature, it begins to combine with the oxygen of the atmosphere, and that this oxygen during its condensation lets go the *latent* caloric, and the light with which it was combined while in the gaseous state. Hence their appearance during every combustion. Hence also the change which the combustible undergoes in consequence of combustion.

It followed from this view, that the metallic *calces* were combinations of metals with oxygen; and on examining the products of certain inflammable bodies, and finding them to be acid, the conclusion was extended by a plausible analogy to other acids whose bases were unknown, and the general proposition was established that oxygen was the universal principle of acidity;

that acids resulted from the union of a peculiar combustible base, called the *radical*, with the common principle, oxygen, technically termed the *acidifier*.

These views, regarding the phenomena of combustion and acidification, may be considered as constituting what has been termed the *Anti-phlogistic system*.

It was some time, however, after this system was promulgated, before its author was able to gain a single convert, notwithstanding his unwearied assiduity, and the great weight which his talents, his reputation, his fortune, and his situation naturally gave him.

At length, M. Berthollet, at a meeting of the Academy of Sciences in 1785, solemnly renounced his old opinions, and declared himself a convert. Fourcroy followed his example, and two years afterwards Morveau, during a visit to Paris, was prevailed upon to embrace the new doctrine.

The theory of Lavoisier, soon after it had been framed, received an important confirmation from the two grand discoveries of Mr. Cavendish, respecting the composition of water and nitric acid, and the elaborate and beautiful investigations of Berthollet into the nature of ammonia; by which, phenomena, before anomalous, were shown to depend upon combinations of aëriform matter.

The notion of phlogiston, however, was still defended with remarkable tenacity by many distinguished philosophers. Mr. Kirwan, who considered hydrogen as the universal principle of combustibility, undertook to prove that this element entered into the composition of every body of the kind; a single exception, of course, must necessarily prove fatal to the theory. Mr. Kirwan, fortunately for the French chemists, founded his reasonings on the inaccurate experiments of other chemists; and thus did he promote the popularity of the anti-phlogistic system by the weakness of the arguments by which he assailed it.

Lavoisier and his associates saw at once the important uses which might be made of this essay: by refuting an hypothesis which had been embraced by the most respectable chemists in Europe, their cause would receive an *éclat* which would make it irresistible. The essay was accordingly translated into French, and each of the sections into which it was divided was accompanied by a refutation.

Four of the sections were refuted by Lavoisier, three by Berthollet, three by Fourcroy, two by Morveau, and one by Monge.

Mr. Cavendish, in a paper communicated to the Royal Society in the year 1784, drew a comparison between the phlogistic and anti-phlogistic theories, and showed that each of them was capable of explaining the phenomena in a satisfactory manner; he however, at the same time, gave the reasons which induced him to prefer the earlier view. In the execution of this task, unlike Mr. Kirwan, he never advanced a single opinion which he had not put to the test of experiment; and he never suffered himself to go any farther than his experiments would warrant. This paper, therefore, the French chemists were unable to refute, and they were accordingly wise enough to pass it over without notice. Had it been possible to have preserved the phlogistic hypothesis, Mr. Cavendish would have saved it—

> " Si Pergama dextrâ
> Defendi possent, etiam hâc defensa fuissent."

"Sooner or later," says Sir Humphry Davy, "that doctrine which is an expression of facts, must prevail over that which is an expression of opinion. The most important part of the theory of Lavoisier was merely an arrangement of the facts relating to the combinations of oxygen: the principle of reasoning which the French school professed to adopt was, that every body which was not yet decompounded, should be considered as simple; and though mistakes were made with respect to the results of experiments on the nature of bodies, yet this logical and truly philosophical principle was not violated; and the systematic manner in which it was enforced was of the greatest use in promoting the progress of science."

Till 1786, there had been no attempt to reform the nomenclature of chemistry; the names applied by discoverers to the substances which they made known were still employed. Some of these names, which originated amongst the alchymists, were of the most barbarous kind; few of them were sufficiently definite or precise, and most of them were founded upon loose analogies, or upon false theoretical views.

"It was felt by many philosophers, particularly by the illustrious Bergman, that an improvement in chemical nomenclature was necessary, and in 1787, MM. Lavoisier, Morveau, Berthollet, and Fourcroy, presented to the world a plan for an almost entire change in the denomination of chemical substances, founded upon the idea of calling simple bodies by some names characteristic of their most striking qualities, and of naming compound bodies from the elements which composed them." There was besides a secret feeling in the breasts of the associated chemists, which, no doubt, had its influence in suggesting and promoting such a scheme. The views of Lavoisier had so changed the face of chemistry, as almost to have rendered it a new science: by adopt-ing a new nomenclature, they identified, as it were, all the discoveries of the day with the new theory, and thus appropriated to France the original and entire merit of the system.

It is impossible to pass over this subject without a comment. Lavoisier was unquestionably indebted to Dr. Black for the support, if not for the suggestion, of the most brilliant part of his theory of combustion; and yet he attempted even to conceal the name of the discoverer of *latent heat.*

How far Lavoisier was really culpable, and whether he did not intend to do full justice to all the claims of his predecessors, cannot now be known; as he was cut off in the midst of his career, while so many of his scientific projects remained unexecuted. From the posthumous works of Lavoisier, there is some reason for believing that, if he had lived, he would have done justice to all parties; but there is no doubt that Dr. Black, in the mean time, thought himself aggrieved by the publication of several of Lavoisier's papers in the "Mémoires de l'Académie," and that he formed the intention of doing himself justice, by publishing an account of his own discoveries: this intention, however, was unfortunately thwarted and prevented by bad health. But to return to the subject of nomenclature. Sir H. Davy continues—"The new nomenclature was speedily adopted in France; under some modifications, it was received in Germany; and, after much discussion and opposition, it became the language of a new and rising generation of chemists in England. It materially assisted the diffusion of the anti-phlogistic doctrine, and even facilitated the general acquisition of the science; and many of its details were contrived with much address, and were worthy of its celebrated authors."

On the general adoption of this new theory of chemistry, it must be admitted that its authors displayed an intemperate triumph wholly unworthy of them. They held a festival, at which Madame Lavoisier, in the habit of a priestess, burnt the works of Stahl on an altar erected for the occasion, while solemn music played a requiem to his departed system!

Sir Humphry Davy, in speaking of the merits of Lavoisier, observes that "he must be regarded as one of the most sagacious of the chemical philosophers of the last century; indeed, except Cavendish, there is no other enquirer who can be compared to him for precision of logic, extent of view, and sagacity of induction. His discoveries were few, but he reasoned with extraordinary correctness upon the labours of others. He introduced weight and measure, and strict accuracy of manipulation into all chemical processes. His mind was unbiassed by prejudice; his combinations were of the most philosophical nature; and in his investigations upon ponderable substances, he has entered the true path of experiment with cautious steps, following just analogies, and measuring hypotheses by their simple relations to facts."

It will be scarcely possible for a future generation of philosophers to imagine with what an undisciplined ardour the anti-phlogistic system, thus enhanced by a new and fascinating nomenclature, was supported throughout Europe. Facts only were appreciated in proportion to the evidence they furnished of its truth; and a discovery even required the sanction of its authority as the passport to notice and regard. The least expression of doubt, as to the validity of any point in its doctrines, exposed the sceptic to a host of assailants, and fortunate was he if he escaped the fate of Peter Ramus, or of those who ventured to question the infallibility of that great despot of another age, Aristotle.

In no country of Europe did this feeling manifest itself to a greater extent than in England. There was perhaps a political prejudice co-operating upon the occasion: it is very difficult, under any circumstances, to avoid connecting the man and his works. The fate of Lavoisier * was truly affecting, and by a species of retributive justice, he received the sympathy of the world in the homage paid to his system; while the atrocity of his assassination, on which every Englishman dwelt with horror, appeared to be thus heightened by every praise bestowed upon his merits.

It is not the least surprising circumstance in the history of this system, that with such a blind and idolatrous admiration of its principles, so few facts should have been distorted. It is true that, from the belief that combustion could never take place without the presence of oxygen, the elementary principle of Scheele became, according to these views, a compound of oxygen and an acid; and the name of *dephlogisticated marine acid* was exchanged for that of *oxymuriatic acid*, a circumstance which spread a cloud of error over the science, and perhaps retarded its progress in a greater degree than is generally imagined. In like manner, the chemist neglected to avail himself of the hint

* Lavoisier perished on the scaffold at the age of fifty-one, during the sanguinary reign of Robespierre. The fury of the revolutionary leaders of France was particularly directed against the farmers-general of the revenue, who were all executed, with the exception of a single individual, a M. de Verdun. Sixty of them were guillotined at the same time, in consequence of a report of Dupin, a frantic member of the Convention. The revolutionary tribunal adopted a general formula, as the ground of their condemnation, which is curious as applied to Lavoisier, who was declared guilty of having "adulterated snuff with water and ingredients destructive of the health of the citizens." The unfortunate philosopher requested time to complete some experiments on respiration. The reply of Coffinhal, the President, was, that "the Republic did not want savans or chemists, and that the course of justice could not be suspended."

which, under other impressions, would have proved an important clue to discovery, *viz.* the acid properties of sulphuretted hydrogen.

We have now arrived at that stage in our history, when it may with propriety and advantage be asked—WHAT HAS DAVY DONE IN CORRECTING ERROR, OR IN ADVANCING TRUTH?

The answer to this question will be nothing more than a summary of those discoveries which have been successively investigated during the progress of the present work.

The new doctrines of chemistry were highly instrumental in encouraging more extended investigations into all the different productions of nature and art; and we may observe, that one of the first efforts of Sir Humphry Davy was to improve our knowledge of the nature and habitudes of the tanning and astringent principles of vegetables,—an enquiry which had been commenced by Seguin and Proust. In pursuing even the most beaten path, he was sure to discover objects of novelty. Look at his early experiments on the cane, and on the straw of wheat, barley, and hay, and we shall see how magically he raised from their ashes a new flower of knowledge. He soon, however, quitted the track of other experimentalists; although we learn from the whole tenor of his researches, that he could obey as well as he could command, and he could act in the ranks, although he more frequently appeared as a general in the field of science.

Sir Humphry Davy has observed, that " at the time when the anti-phlogistic theory was established, electricity had little or no relation to chemistry. The grand results of Franklin respecting the cause of lightning, had led many philosophers to conjecture, that certain chemical changes in the atmosphere might be connected with electrical phenomena; and electrical discharges had been employed by Cavendish, Priestley, and Van-Marum, for decomposing and igniting bodies; but it was not till the era of the wonderful discovery of Volta, in 1800, of a new electrical apparatus, that any great progress was made in chemical investigation by means of electrical combinations.

" Nothing tends so much to the advancement of knowledge as the application of a new instrument. The native intellectual powers of men in different times are not so much the causes of the different success of their labours, as the peculiar nature of the means and artificial resources in their possession. Independent of vessels of glass, there could have been no accurate manipulations in common chemistry: the air-pump was necessary for the investigation of the properties of gaseous matter; and without the Voltaic apparatus, there was no possibility of examining the relations of electrical polarities to chemical attractions."

There is a candour in this statement which we cannot but admire. Nor does the admission diminish the glory of him who, by the application of such new instruments of research, was enabled to penetrate into the hidden mysteries of Nature. What avails the telescope, without the eye of the observer?

To Davy, the Voltaic apparatus was the *golden branch*, by which he subdued the spirits that had opposed the advance of former philosophers; but what would its possession have availed him, had not his genius, like the ancient Sibyl, pointed out its use and application?

It will be seen that he was thus enabled, not only to discover laws which are in constant operation, modifying the forms of matter, and influencing all the operations of chemistry, but by applying them, to determine the elements of the fixed alkalies to be oxygen and a metallic base: a fact obviously opposed to the idea of oxygen being the general principle of acidity; for here it was the principle of alkalinity, if it may be so expressed. This was shaking the corner-stone of the edifice, and his subsequent researches into the nature of oxy-muriatic acid may be said to have overthrown it; for if either of the elements of this body can be considered as the acidifier, it is hydrogen. The consequences which flowed from this truth were of the highest importance, not only in correcting errors, which the progress of discovery, instead of rectifying, was actually multiplying, but in leading to the developement of new bodies. Iodine might have been recognised as an elementary body, but its relations to oxygen and hydrogen would probably have remained unknown, had not a knowledge of the true character of chlorine assisted the enquiry.

The same observation will apply to the recently-discovered body, Bromine. In like manner has the chemist been led, by the chloridic theory, to a more accurate acquaintance with the composition of the fluoric, hydriodic, and hydrocyanic acids; while he has also learnt that hydrogen alone can convert certain undecompounded bases into well characterised acids, without the aid of oxygen. The same discovery has completely changed all our opinions with regard to a very important series of saline combinations, and developed the existence of new compounds of a most interesting description.

Thus, then, has the *acidifying* hypothesis of Lavoisier been overturned, and a new theory constructed out of its ruins, which acknowledges no distinct element as the one imparting to matter the characters of an acid.

Equally complete has been the downfal of the theory of combustion. The discovery of the true nature of chlorine was, in itself, sufficient to show that bodies might combine, with the phenomena of heat and light, without the presence of oxygen; but Davy has brought a mass of evidence from other sources in proof of the same truth. He has shown that, whenever the chemical forces which determine either composition or decomposition are energetically exercised, the phenomena of combustion, or incandescence, with a change of properties, are displayed. He has therefore annulled the distinction between supporters of combustion and combustibles, since he has shown that, in fact, one substance frequently acts in both capacities, being a supporter *apparently* at one time, and a combustible at another. But in both cases the heat and light depend on the same cause, and merely indicate the energy and rapidity with which reciprocal attractions are exerted. Thus sulphuretted hydrogen is a combustible with oxygen and chlorine; a supporter with potassium. Sulphur, with chlorine and oxygen, has been called a combustible basis; with metals, it acts the part of a supporter. In like manner, potassium unites so powerfully with arsenic and tellurium as to produce the phenomena of combustion. Nor can we ascribe the appearances to the liberation of latent heat, in consequence of condensation of volume. The protoxide of chlorine, a body destitute of any combustible constituent, at the instant of decomposition evolves light and heat with explosive violence; and its volume becomes one-fifth greater. Chloride and iodide of azote, compounds alike destitute of any inflammable matter, according to the ordinary belief, are resolved into their respective elements with tremendous force of inflammation; and the first expands into more than six hundred times its bulk. Now, instead of heat and light, a prodigious degree of *cold* ought to accompany such an expansion, according to the hypothesis of latent heat. Other instances might be cited, and other arguments adduced on the same subject, but time and space fail me.*

Such, then, are the facts developed by the experimental researches of Sir Humphry Davy; from which it follows, that—

1. Combustion is not necessarily dependent on the agency of oxygen.

2. That it cannot be regarded as dependent upon any peculiar principle or form of matter, but must be considered as a general result of intense chemical action.

* The reader who wishes for further details, will consult with advantage the article Combustion in Dr. Ure's Dictionary of Chemistry; a work to which I acknowledge myself much indebted on this and other occasions.

3. That the evolution of light and heat cannot be ascribed simply to a gas parting with its latent store of those ethereal fluids.

4. That, since all bodies which act powerfully upon each other are in the opposite electrical relations of positive and negative, the evolution of heat and light may depend upon the annihilation of these opposite states, which will happen whenever they combine.

Thus has Sir H. Davy, by refuting the opinions of the French philosophers, respecting the relations of oxygen to the phenomena of combustion, and the nature of its products, removed the pillars on which the fabric of the anti-phlogistic rested, and reduced the generalization of Lavoisier to isolated collections of facts; the sound logic, however,—the pure candour, the numerical precision of inference which characterise the labours of the French philosopher, will cause his name to be held in everlasting admiration. The downfal of his doctrine is the natural result of the progress of truth; the same fate may attend our present systems, but the facts discovered through their means are unchangeable and eternal; and it is upon them alone that the fame of the chemist must ultimately rest.

In sciences collateral to chemistry, the researches of Davy have cast a reflected lustre. In geology, his discovery of the composition of the earths, has opened a new path of investigation; while his examination of the water and gaseous matter so frequently enclosed in the cavities of quartz has given no small degree of support to the hypothesis of the Plutonists; above all, his results connected with the decomposition and transfer of different elements by Voltaic influence, has already explained many phenomena relating to metallic veins; and the late researches of Mr. Fox must lead us to the conclusion, that electric powers are still in operation in the recesses of the earth; and that mineral veins are not only the cabinets of Nature, but still her active laboratories.

These cursory observations upon the discoveries of Sir H. Davy relate merely to the changes they have effected in the general theory of chemistry. I might recapitulate the numerous researches by which he has extended our knowledge upon particular subjects; but I have so fully entered into the consideration of them in the body of my work, that I consider such a tax upon the patience of my reader would be both unfair and unnecessary.

I shall therefore *conclude* my long and arduous labour, by enumerating the different memoirs communicated by this distinguished philosopher to the

Royal Society; and also the several works which he published at different periods of his brilliant but too fleeting career.

1. An Account of some Galvanic Combinations, formed by single metallic plates and fluids, analogous to the Galvanic Apparatus of M. Volta. *Read June* 18, 1801.

2. An Account of some Experiments and Observations on the constituent parts of certain Astringent Vegetables, and on their operation in Tanning. *February* 24, 1803.

3. An Account of some Analytical Experiments on a Mineral Production from Devonshire, consisting principally of Alumina and Water. *February* 28, 1805.

4. On a Method of analysing Stones containing a fixed Alkali, by means of Boracic acid. *May* 16, 1805.

* *For the above papers, the Society awarded him the Copley Medal.*

5. THE BAKERIAN LECTURE.—On some chemical agencies of Electricity. *Read November* 20, 1806.

** *For this memoir, he received the prize of the French Institute.*

6. THE BAKERIAN LECTURE.—On some new Phenomena of Chemical Changes produced by Electricity, particularly the Decomposition of the Fixed Alkalies, and the exhibition of the new substances which constitute their bases; and on the general nature of Alkaline bodies. *Read November* 19, 1807.

7. Electro-chemical Researches on the Decomposition of the Earths; with Observations on the Metals obtained from the Alkaline Earths; and on the Amalgam procured from Ammonia. *June* 30, 1808.

8. THE BAKERIAN LECTURE.—An Account of some new Analytical Researches on the nature of certain bodies, particularly the Alkalies, Phosphorus, Sulphur, Carbonaceous matter, and the Acids hitherto uncompounded; with some general Observations on Chemical Theory. *December* 15, 1808.

9. New Analytical Researches on the nature of certain bodies; being an Appendix to the Bakerian Lecture for 1808. *February* 1809.

10. The Bakerian Lecture for 1809. On some new Electro-chemical Researches on various objects, particularly the metallic bodies from the Alkalies and Earths; and on some combinations of Hydrogen. *Read November* 16, 1809.

11. Researches on the Oxy-muriatic Acid, its nature and combinations; and on the elements of Muriatic Acid; with some Experiments on Sulphur and Phosphorus, made in the Laboratory of the Royal Institution. *July* 12, 1810.

12. The Bakerian Lecture for 1810.—On some of the Combinations of Oxy-muriatic Gas and Oxygen, and on the chemical relations of those principles to inflammable bodies.
November 15, 1810.

13. On a Combination of Oxy-muriatic gas and Oxygen gas.
February 21, 1811.

14. On some Combinations of Phosphorus and Sulphur, and on some other subjects of Chemical Enquiry.
June 18, 1812.

15. On a new Detonating Compound; in a letter to Sir Joseph Banks, Bart. F. R. S. *November* 5, 1812.

16. Some further Observations on a new Detonating substance.
July 1, 1813.

17. Some Experiments and Observations on the Substances produced in different chemical processes on Fluor Spar.
July 8, 1813.

18. An account of some New Experiments on the Fluoric Compounds; with some Observations on other objects of chemical enquiry.
February 13, 1814.

19. Some Experiments and Observations on a new Substance, which becomes a Violet coloured Gas by heat.
January 20, 1814.

20. Further Experiments and Observations on Iodine.
June 16, 1814.

21. Some Experiments on the combustion of the Diamond, and other Carbonaceous Substances.
June 23, 1814.

22. Some Experiments and Observations on the Colours used in Painting by the Ancients. *Read February* 23, 1815.

23. Some Experiments on a solid Compound of Iodine and Oxygen, and on its chemical agencies.
April 20, 1815.

24. On the action of Acid upon the Salts usually called *Hyper-Oxymuriates,* and on the Gases produced from them.
May 4, 1815.

25. On the *Fire-Damp* of Coal Mines, and on methods of lighting the Mine, so as to prevent Explosion.
November 19, 1815.

26. An Account of an Invention for giving Light in Explosive Mixtures of *Fire-Damp* in Coal Mines, by consuming the Fire-Damp.
January 11, 1816.

27. Further Experiments on the Combustion of Explosive Mixtures confined by Wire Gauze, with some observations on Flame.
January 25, 1816.

28. Some Researches on Flame.
January 16, 1817.

29. Some New Experiments and Observations on the Combustion of Gaseous Mixtures; with an account of a method of preserving a continued Light in Mixtures of inflammable Gases and Air, without Flame. *January* 23, 1817.

*** *For the above five papers, the Rumford Medals were awarded to him.*

30. On the fallacy of Experiments in which Water is said to have been formed by the decomposition of Chlorine.
February 12, 1818.

31. New Experiments on some of the combinations of Phosphorus.
April 9, 1818.

32. Some Observations on the formation of Mists in particular situations.
February 25, 1819.

33. On the Magnetic Phenomena produced by Electricity.
November 16, 1820.

34. Some Observations and Experiments on the Papyri found in the ruins of Herculaneum. *March* 15, 1821.

35. Further Researches on the Magnetic Phenomena produced by Electricity; with some New Experiments on the properties of Electrified bodies, in their relations to conducting powers and temperature. *Read July* 5, 1821.

36. On the Electrical Phenomena exhibited *in vacuo.* *December* 20, 1821.

37. On the state of Water and Aëriform matter in cavities found in certain Crystals. *June* 13, 1822.

38. On a New Phenomenon of Electro-Magnetism. *March* 6, 1823.

39. On the application of Liquids formed by the condensation of Gases, as mechanical Agents. *April* 17, 1823.

40. On the changes of volume produced in Gases, in different states of density, by Heat. *May* 1, 1823.

41. On the Corrosion of Copper Sheathing by sea-water; and on methods of preventing this effect, and on their application to ships of war and other ships. *January* 24, 1824.

42. Additional Experiments and Observations on the application of Electrical Combinations to the preservation of the Copper Sheathing of ships, and to other purposes. *June* 17, 1824.

43. Further Researches on the preservation of Metals by Electro-chemical means. *June* 9, 1825.

44. The Bakerian Lecture for 1826.—On the Relation of Electrical and Chemical changes. *June* 3, 1826.

**** *For this memoir, the Royal Society conferred upon him the Royal Medal.*

45. On the Phenomena of Volcanoes. *March* 20, 1828.

46. Account of some Experiments on the Torpedo. *November* 20, 1828.

HIS PUBLISHED WORKS ARE,

"Experimental Essays on Heat, Light, and on the Combinations of Light, with a new Theory of Respiration," &c. Published in *Contributions to Physical and Medical Knowledge, by T. Beddoes, M. D.* 1799.

"Researches Chemical and Philosophical, chiefly concerning Nitrous Oxide, and its Respiration." 1800.

"A Syllabus of a Course of Lectures."

"An Introductory Lecture." 1801.

"Elements of Chemical Philosophy." 1812.

"Elements of Agricultural Chemistry." 1813.

"On the Safety Lamp for Coal Miners; with some Researches on Flame." 1818. (Several Editions).

"Salmonia; or Days of Fly-Fishing."

"Consolations in Travel; or the Last Days of a Philosopher."

APPENDIX.

EXTRACTED FROM THE REGISTRY OF THE PREROGATIVE COURT OF CANTERBURY.

A.

MY WILL.

This 3rd of January 1827 feeling more than usual symptoms of mortality I make this my Will. First, I give my Brother John Davy M. D. three hundred pounds a-year of money that I possess in the Long Annuities and likewise four thousand pounds to be raised by the sale of Securities I possess in the English or French funds or annuities but I mean my said Brother to devote the interest of three thousand pound of these last moneys to such purposes as he may deem fitting for the benefit of my sisters particularly my married one and I wish a part of the interest of these three thousand pounds to be employed in educating and settling in life my godson Humphrey Millett. I leave him Dr. Davy likewise all the property devolving to me from my parents which has never been divided to do what seems to him best for the benefit of my sisters and my sister Millett's children and I leave my said brother my Chemical Books and Chemical MSS. Apparatus *Sporting tackle* Medals and the silver Venetian dish made from the Rumford Medal in token of my affection. I leave £100 to each of these friends Dr. Babington and Dr. Franck and £50 to Dr. Wilson Philip and to Mr. Brodie surgeon to lay out in tokens of remembrance. I leave all my other property whether in goods money chattells funded securities annuities or plate to my wife (Lady) Jane Davy and I appoint her the sole Executrix of this my Will. If my brother or his family should not be in a condition at the time of her decease to use my service of plate given for the safety lamp I wish it to be sold and the same given to the Royal Society to provide an annual medal from the interest for the best discovery made any where in chemistry and I depend upon my dear wife to make such presents in seals or token to such of my friends as she may think proper agreeably to their and her feelings.

H. Davy.

B.

Further explanatory Clause.

I leave to my wife Dame Jane Davy all my other property whether funded or in government securities or in leases of houses or goods &c. and I leave her my sole residuary legatee and sole Executrix. I wish her to enjoy the use of my plate during her life and that she will leave it to my brother in case he survive her and if not to any child of his who may be capable of using it but if he be not in a situation to use or enjoy it then I wish it to be melted and given to the Royal Society to found a medal to be given annually for the most important discovery in Chemistry any where made in Europe or Anglo-America. Knowing the perfect understanding and love of justice of my wife I leave to her all other arrangements which may make my memory useful to the world and awaken the kind feelings of my friends and I wish her and my brother and all my friends every happiness this life can afford.

HUMPHRY DAVY.

C.

That is a clause explanatory of my Will.

I wish seals not rings with a fish engraved upon them to be given to some of my friends amongst whom I mention Mr Knight Dr Babington Mr Pepys Mr Hatchett. And lest there should be any doubt respecting the £3000 mentioned I mean my brother to be a trustee for this and should he die without children I mean it to belong to my sister Millett's children £2000 to Humphry Millett my godson and the rest to be equally divided between the other children but should my brother marry and have children I then mean after the death of my sisters these £3000 to be divided between her child or children and my sisters and £1000 to go to Humphry Millett my godson and £500 to my sister's other children leaving the arrangement to my brother.

H. D.

D.

Further explanatory Clause, Feb. 27th 1828.

I leave to my brother John Davy M.D. the proceeds of my Agricultural Chemistry in the future editions and the profits of my work on fishing and I give him the copyright. I leave my friend Thomas Poole Esq. of Stowey fifty pounds to purchase some token of remembrance.

H. D.

Rome Nov. 18th 1828.

By this addition to my will I confirm all that I have willed in a paper left in a brass box at Messrs Drummond leaving Lady Davy my sole Executrix and residuary legatee. I leave the copyright of Salmonia to my brother John Davy wishing him to apply a part of the profits of the sale of the editions of this work to the education of my nephew Humphrey Millett in case he has no children of his own. I leave the copy of my Vision in my writing desk to Lady Davy to be published if my friends think it may give pleasure or information to the public but I wish the profits of this work to be applied to the use of my brothers and sisters. I leave to Josephine Detela daughter of Mr. Detela of Laybach in Illyria inn-keeper my kind and affectionate nurse one hundred pounds or rather a sum which shall equal a thousand florins to be paid out of the balance at my banker's within three months after my decease. I beg Lady Davy to be so good as to fulfill my engagements with the persons who are travelling with me but without any favour as I have no reason to praise either their attention or civilities within the last two months but the kindness and attentions of Josephine Detela during my illness at Laybach not only calls for the testimony I have given but likewise my gratitude for which I give her the £100 or the 1000 florins.

H. Davy.

Feb. 19th 1829.

I wish to be buried where I die *natura curat suas reliquias.* I wish £100 to be given to George Whidby and I beg Lady Davy to fulfill all my engagements and that if my friends should think my Dialogues worthy of publication I beg that they may be published and that Mr. Tobin may correct the press of them and I wish that £150 may be given to him for this labour. There is a codicil to my will in my writing desk. I beg Lady Davy to have the goodness to attend to every thing mentioned in that. In addition to what I have mentioned in that codicil I request that £50 or 500 florins may be given to Josephine Dettela within five months after my decease and I wish £50 to be presented to my friend Dr Morichini in remembrance and memory of his great kindness to me.

H. D.

I wish one hundred to be given to my amanuensis.

For the purpose of explaining a Will that I made before I left England and some papers that I have since added to it I write these few words Rome, March 18, 1829.

I give the copyright of Salmonia my Dialogues and any other of my works which my friends may think it proper to republish to my brother John Davy M.D. to be published in the manner he may think most fit and proper. I have already in my former testament left Lady Davy my residuary legatee but I beg her in considering the disposition of my property to regard £6000 as belonging to my brother Dr. Davy in case there rests any doubt upon this subject in my first will and I wish her the said Lady Davy to enjoy during her life the use and property of the different services of plate given to me whether by the Emperor of Russia or the different coal *committees* but I trust to her sense of justice that she will leave them in the manner I have pointed out in my will to my brother. With respect to any property at present in my banker's hands or any thing I now carry with me I leave them entirely to my brother Dr. Davy.

Humphry Davy.

At Rome March 18, 1829.

THE END.

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