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INTRODUCTION.

The readers of a new Periodical are fairly entitled to receive at the hands of its projectors, not only a statement of the grounds upon which it has been established, but also some exposition of its intended scope and objects.

The word "some" is here designedly used, for it is not improbable that a work of this description, professing to keep pace with the advancing intelligence of mankind, and even, should opportunities present themselves, to serve as a pioneer of progress, may in the course of time become so modified as materially to change its character. And as we are fortunately not trammelled by those conditions which in the commercial world frequently place limits upon a project when it is first set on foot, we shall reserve to ourselves the right of introducing amendments, or of supplying deficiencies as our work proceeds, adopting the old proverb that "Times change, and with them we shall change also." As this may appear a somewhat vague announcement of our plans, we will shortly conduct our readers to a standpoint from whence they may obtain a survey of the field of our intended labours, and in the meantime we would invite them to follow us in a few reflections which have been the cause of our venturing, at this particular period, into the ranks of literature.

How does it happen that from the earliest ages of the historic record, Art has been a favoured offspring of the human intellect, the spoiled child of man, whilst to Science he has been but a sorry stepfather? In his rudest stages, he wooed her favour, painting his own skin if he could paint nought else, and in the palmy days of his early civilization he raised her upon a pedestal from which she never descended, although in the dark ages that followed, her figure was for the time obscured. Not so with Science. Her youthful steps have always been watched with jealousy and suspicion, and instead of guidance and support, every obstacle has been thrown in her path, her grandest revelations being frequently held up to scorn and obloquy, and twisted and tortured until they were made to appear the teachings of the Evil One.

We have but to place side by side the artist whose employment has been to copy the works of nature, and the student who has enunciated her laws; or the modeller in stone, and the teacher of those truths which even stones reveal; and what a contrast do they afford! The labours of the one have been rewarded with a wreath of laurel, whilst a crown of thorns has ever fallen to the other's lot.

How is this phenomenon to be explained? Can it be—and we make the inquiry with due appreciation of her elevating tendencies—can it be that the ways of Art are elastic and accommodating, and that without distinction of sect or creed, she has always been the servant of Theology, doing duty alike for Hebrew and Greek, Mahommedan and Christian, whilst Science has held aloof from all these denominations and has walked only with the religion taught by nature? Or is it that the truths of Science can only be understood and appreciated by the cultivated intellect, whilst the beauties of Art impress themselves upon the unaided sense?

We refrain from pressing the inquiry further, lest it be imagined that we would seek to elevate our mistress at the expense of a sister, or that we are assuming a petulant tone and an attitude of hostility towards one with whom we desire to walk hand in hand, and to whom also our co-operation is daily becoming more indispensable.

Leaving our readers, then, to work out the problem for themselves as regards the past, we proceed to inquire whether the existing state of things holds out a more hopeful prospect to Science and her votaries; and here the replies are sufficiently plain and satisfactory.

A certain amount of scientific knowledge is now absolutely necessary to men of all ranks, and forms an essential element in a liberal education. The influence of scientific discovery is becoming daily more powerful, and is making itself felt in almost every vocation of life. Science not only succours the wounded on the battle-field, but without her powerful aid, bravery is of no avail in the General, nor in the ranks. The loud and fluent tongue of the pleader may seek to persuade, but without the unobtrusive evidence of the man of science it fails to convince. The tiller of the soil may labour unremittingly with his hands, and waste the sweat of his brow, but his neighbour looks on, smiling, and lets the steam-engine perform his work more speedily and at a smaller cost. And so it is everywhere,—in the factory or mine, in the university or schoolroom, in the world of pleasure as in the world of pain.

It is true that, for the moment, a few theologians and politicians are inclined to underrate her influence, and even in some instances to close their ears to her teachings; but these are exceptional cases, and those who "waste their philosophic pains" in thus endeavouring to stem the tide of progress, will one day find themselves drifting alone down the current with which they might have sailed in the company of their fellow-travellers on the way to Truth.

Scientific knowledge is now eagerly sought, and its possessors are respected. Here and there a few impetuous workers or thinkers give utterance to tenets which shock the temperate and cautious, and lead the pious to believe that another golden calf is about to be set up for worship; but these are the exceptions, and compared with Theology and Politics, Science has but few extremists. As, however, her devotees are rather men of thought and action than of wordy eloquence, they are often less appreciated than the fruits of their labours, and thus it happens that the astute politician or the talented historian may edge his way on to the Treasury Bench, or arrive at the dignity of a Peerage, and the eloquent Theologian may succeed in reaping a Bishopric, whereas the able man of science whose labours have changed the destiny of nations, or who has given a new direction or a fresh impulse to the course of civilization, must content himself with a Knighthood, or declining that, must rest satisfied with the honourable letters affixed to his name by his fellow-labourers, and leave it to posterity to raise an enduring monument to his memory.

Still, as we have said, Science is beginning to exercise a potent influence in every circle of society, and not only does she reckon amongst her followers multitudes of the labouring classes (so many, indeed, that it has been found necessary to organize a special department and machinery in the State to aid them in the pursuit of this species of knowledge), but even lords and statesmen who had previously bestowed all their favours upon the nurseries of literature, are now beginning to cast tender glances upon Schools of Science, and other similar institutions. The discoveries of unwearying investigators, too, and the explorations of bold adventurers on the earth or sea, or in the air, are no longer published in ponderous tomes and modest "brochures," but find a rapid utterance in special periodicals, and even in the flying sheets of the daily press,—those great organs of public opinion without which no man can live the life of the nineteenth century.

Thus much by way of preface to the consideration of the present state of Scientific knowledge; but if, from a theme so noble and inspiring, we have been able to derive so little eloquence, what words shall we find to plead our own cause? As we approach the subject, we feel as does the candidate for public suffrage, who comes before the constituency primed with eloquent appeals and telling periods, but who, when he sees the crowd of curious upturned faces, concealing tongues ready to applaud, but equally prompt to hiss, finds that his labelled sentences are gone, and with them his courage to seek fresh ones.

Let us, then, be brief.

We have been told by men in every walk of life, that the time is come when Science may claim for herself a special organ; that not alone scientific readers, but those of every class, desire to approach the source from whence this species of knowledge is derived,—to learn in which direction the current flows, and how it is likely to affect their material interests or questions bearing upon their eternal happiness.

To supply such a want is a truly ambitious aim, and one which, we do not hesitate to confess, we should never have proposed to ourselves had we not been first assured of the co-operation of those whose powers alone are equal to its accomplishment.

With men illustrious in Science, ready to avail themselves of these pages as a medium of communication with the public, and to many of whom we acknowledge ourselves already indebted, both for friendly counsel and for active co-operation, we now set out, full of hope and confidence; and before giving place to those whose words will have much weight, and whose teachings cannot fail to exercise a beneficial influence, we invite our readers to advance a few paces with us, to an eminence from which we may be enabled to point out to them some of the more prominent farmsteads on the surrounding fields of Science, where the labourers are to-day busy sowing or reaping, enriching old, or winning new pastures.

This figurative remark naturally leads us to the consideration of one or two of the more prominent features in connection with the Science and practice of Agriculture as they are to-day presented to our notice; and, perhaps, no subject is more deserving of attention at our hands than the Drainage and Cultivation of land.

It is, probably, unknown to the large majority of our readers, that a legislative enactment was passed, a few years since, called the "Land Drainage Act," the object of which was to enable proprietors of arable and pasture land situated in valleys or level districts more effectually to drain such land by the acquisition of a convenient access to what are termed the arterial drains (the smaller streams and rivers); in fact, to give them what, in the railway world, would be called "running powers" for a drain through a neighbour's estate.

When they are informed that by improved drainage the rental of some kinds of land may be raised from 5*s.* or 6*s.* to 40*s.*, or even 50*s.* an acre, whilst the poorer soils are capable of being enhanced fourfold, our readers will perceive this movement to be one of great practical importance. To do our English landowners and farmers justice, it would appear that they have always been willing to grant this accommodation to a neighbour, but, owing to the laws of entail and other conditions of society, this has been but a fleeting privilege, and should the obliging neighbour die, and be followed in the possession of his estate by one less accommodating, the outlet might at any moment be blocked up or otherwise intercepted, and then the owner of the drained land would have no power to cause it to be cleared or reconstructed.

Several previous attempts had been made to remedy this evil by legislative enactments, all of which proved futile; but under the new Act (which appears to have objectionable as well as advantageous features) a local Board may now be formed, having power to assess a rural district precisely as in the case of a "commission of sewers." The method by which it is intended to improve the drainage of land is by doing away with those mill-dams which interfere with the free current of an arterial drain, as well as through the utilization of others by which the flow is facilitated; by collecting and storing up surplus water, and preserving it for seasons of drought; and pumping stagnant water by mechanical power from low to high levels, and thence directing it into arterial drains. To attain these objects, it is requisite to secure the hearty co-operation of whole agricultural districts, and owners of land should not look to their own immediate interests alone, but should consider the welfare of their neighbours and posterity.

The promoters of such movements as these will find us ever ready to advocate their cause and give publicity to their reasonable suggestions.*

But good drainage alone is not a sufficient preparation of the soil for the reception of the parent seed; deep and constant furrowing are also requisite, and for this purpose steam is rapidly and advantageously superseding horse-power. The work is accomplished more efficiently and speedily, and there are descriptions of soil, and seasons when it would be absolutely ruinous to allow horses to tread the land whilst dragging the plough, whereas no obstacle whatever is opposed to steam traction. Indeed, the substitution of the latter for the former has, no doubt, frequently gained a season to the farmer, as his improved harvesting implements have saved him a valuable crop.

It is hardly needful to add, that with improved drainage and cultivation of the soil, the farmer secures more valuable produce. Light,

* Mr. J. Bailey Denton has been most active in bringing about improved drainage, and in procuring enactments for the purpose.

scanty grain gives place to the full rich ear, and succulent grasses and clovers supplant the poorer kinds; in fact, the "conditions of existence" are altered, and the weed no longer finds a genial bed. The soil prepared, we next come to the seed; and here, too, the agriculturist has enlisted science in his cause. Two attempts are being made to increase the produce of cereals: one by the use of what is termed "pedigree seed;" that is, a seed derived from repeated selections of the finest ears—the original parent being an ear of great size —by artificial selection, in fact; the other by artificial fructification. Our limited space will not permit us to dwell upon either of these systems, which will probably be treated in detail hereafter by abler pens than ours; and we must refer to the farmer's last trouble—save and except the conversion of his harvest into gold, in which process he stands in need of other speculations than those of scientific men—we mean the saving of his produce, or, we might almost say, the conquest of the elements.

The improvements which are daily taking place, to enable him to expedite and cheapen his harvest operations, deserve, and will receive a special place with us. The reaping and mowing machines which have been some time in use in America are now approaching perfection in England, and the haymaking machine has already rescued many a crop that would otherwise have been sacrificed. A little more speed; a few more applications of scientific principles; and the farmer may defy or wield the weather as he already manipulates and utilizes the soil.

But whilst the agriculturist turns with disfavour from the time-honoured running stream, and, pronouncing water-wheels a nuisance, calls in the aid of the steam-engine to every portion of his rapidly-progressing work, a leading mechanician steps forward, and warns us of the necessity of economizing coal and of utilizing water-power, lest the supply of the former should become exhausted. In his opening address, the President of the British Association startled the world, and more especially the geological world, with the announcement, that should the consumption of coal increase at its present rate, two centuries only will be the duration of the supply from the North Country coal-field; and that, if no greater economy be exercised than at present, a hundred years will suffice to bring about this result.

Whatever may be the value of this speculation, its propounder has been led by the consideration of the subject to practical conclusions, perhaps not novel ones, but of great importance to the community, in regard to the present mode of employing this precious fuel. He has shown that improved machinery, a better arrangement of the firegrate, and an easy method of firing, would not only economize its consumption to an almost incredible degree, but that the inhabitants of cities would be spared the annoyance and inconvenience of a vitiated atmosphere. Even in our present fireplaces, he tells us, we consume five times as much coal as would be requisite in a properly constructed stove or improved open fireplaces.

As regards the substitution of stoves for firesides, we suspect that our countrymen would rather dispense with coal altogether and return to the days of wood and turf, than allow such an innovation; but, as we shall have occasion to show hereafter, striking improvements are being introduced into the construction of land and marine engines, which herald a constantly increasing economy in the consumption of coal.

It would appear, however, from the opinions expressed by experienced practical geologists, that it is difficult at present to estimate even the exact area of our English coal-beds, and it is believed that the fields now worked will yield a sufficient supply of fuel to last nearly a thousand years.*

Leaving this subject, we have now to observe that the exploration of one new field has already produced results almost as startling, and certainly not less useful than the speculations of Sir William Armstrong. In sinking a shaft at Middlesborough, for the purpose of obtaining a supply of fresh water, Messrs. Bolckow and Vaughan, the enterprising pioneers of the coal and iron trade in that district, were so fortunate as to discover at a depth of twelve hundred and six feet, in the Trias, or New Red Sandstone formation, a deposit of rock salt, which, in August last, had been penetrated to the depth of nearly one hundred feet, without its lowest limit having been reached; and the brine, which was found to contain ninety-six per cent. of chloride of sodium, has been pronounced by an experienced chemist to be purer than that of Cheshire.

It is almost impossible for persons unacquainted with the mineral and manufacturing districts of Northumberland to form any conception of the importance of this discovery.

Hitherto, the soda manufacture of the Tyne has been entirely dependent for its supply of salt (from which the various preparations of soda are manufactured) upon the brine-springs of Cheshire and Worcestershire, and from these two counties at least one hundred thousand tons of salt have been conveyed annually, at a cost, in some cases, far exceeding the value at the works, of the mineral itself. Should the Cleveland salt-beds prove productive, the Newcastle soda

* For further information on this topic, we refer our readers to an article in the present number, on the "Coal Resources of Great Britain," by Mr. E. Hull.

makers will, of course, be greatly benefited, and will compete more successfully than they do at present with the Lancashire manufacturers for the supply of all the western markets.

As to the fortunate ironmasters, they will not only have found an unexpected mine of wealth in the salt-beds, but in the evaporation of the brine, they will be enabled to utilize the waste heat from their puddling and blast furnaces, as well as from their coke-ovens; thus adding profit to profit, and carrying out in an unexpected manner the economical principles recommended by the President of the British Association.

Closely allied to the question of Coal, is that of Petroleum—a natural product which is likely to exercise an important influence upon civilization. This hydro-carbon, some forms of which have long been known in India, has recently been found to exude from certain wells or springs in Pennsylvania and Canada. It is supposed to arise from the destructive distillation of a mineral bitumen beneath the surface, and on reaching the hand of man, it is subjected a second time to the distilling process, when it yields three distinct substances of considerable value. The first is a spirit, which is employed as a cheap substitute for turpentine; the second, a burning oil of great brilliancy, capable of being used in lamps of an almost nominal value, and itself procurable at an average price not exceeding half that of rape-oil;* and lastly, a kind of grease which is employed for lubricating coarse machinery. The importation of this substance (chiefly in its distilled form) is increasing rapidly, and may be reckoned by millions of gallons, and almost the only thing requisite to enable it to rank amongst our leading commercial staples, is an inexpensive air-tight cask, in which it may be stored, so as to obviate the enormous leakage which often causes it to be a ruinous venture to importers and dealers.

These are but two or three of the interesting results or applications of that geological knowledge, the development of which must necessarily occupy a prominent place in our pages; and being of a practical character, we have selected them for comment, in preference to those which bear upon the principles of the science itself, such as the Origin of Rocks, Earthquakes,† the Palæontological Evidences as to the Antiquity of the Human Race, and many other subjects which are now engaging the attention of scientific men.

Before quitting *terra firma* to follow the researches of Science into space, we must direct our attention for a few moments to the work of

* The wholesale price of the finest Petroleum Oil is now (November) one shilling and ninepence per gallon; of Rape or Colza Oil, three shillings and eightpence per gallon.

† On this subject, an article will be found in the present number, by Mr. Mallett.

Geographical Exploration, a subject of great interest in all literary, scientific, and political circles.

A new era is dawning upon the profession of the traveller, and those attributes which found their embodiment in the fictitious but far-famed German Baron Münchausen, are fast giving place to scrupulous care and accuracy in the description of places, and great modesty in the narrative of personal adventures.

This change is due in part to the general diffusion of knowledge amongst the masses, which enables men more readily to detect error and exaggeration; partly to the progress of the photographic art,* which is incapable of misrepresentation, and in a large measure to that wholesome competition amongst travellers themselves, which soon leads to the contradiction or verification of strange and novel discoveries. Amongst those who have earned for themselves a reputation for bravery and endurance, and who at the same time set an example of the virtue of modesty in the traveller, are the discoverers of the Source of the Nile, and the explorers of Central Australia.

It would be impossible for us even to refer to the adventures of Speke and Grant on their journey from Zanzibar to Lake Nyanza, where the source of the Nile was discovered, and thence down the great river into civilized Africa. Their discoveries have been aptly compared by Mr. Crawfurd to those of Columbus, and the practical benefits which are likely to follow them through the introduction or improved cultivation of useful products of the soil, and the civilization of barbarous peoples, will, in this case as in that of Burke and Wills, recompense the world for the loss of many of its best sons in the service of exploration.

But whilst we give a meed of praise to these adventurous travellers, we consider it right also to inquire whether or not the governments of civilized Europe, and more especially our own legislators, are bearing their share of the burden, and extending a fair amount of support to those who risk their lives in the cause of civilization.

This question will be answered best by a reference to what is passing in those regions of Western Equatorial Africa which have so long been the seat of the slave-trade and of human sacrifices. His Majesty the King of Dahomey must begin to have an elevated notion of his own importance, as traveller after traveller, and one representative after another from the Courts of Europe, solicits his permission to visit him, and to remonstrate with him upon the errors

* No traveller can plead the excuse that photography is difficult of application, after what was accomplished by Professor Piazzi Smyth, at an altitude of 10,700 ft. above the sea level, during the Teneriffe expedition.

of his ways; and if these numerous visits have brought about no other improvement in the untutored mind of the sable despot, they have at least imparted to it diplomatic powers which would reflect credit upon any European autocrat. It is quite amusing to observe how he "cuts his cloth according to his pattern," flattering one traveller and slighting another, as the force of circumstances may direct.

Amidst the conflicting accounts received from Wilmot, Burton, Craft, and Gerard,* it is difficult to form a correct estimate of his character, but a comparison of the narratives of all these travellers, with that of Speke and Grant concerning the kings on the route taken by them, leaves but little doubt that, in common with that of most of these sable monarchs, his every-day rule is characterized by cruelty, superstition, avarice, and almost every conceivable form of licentiousness and oppression.

Why, then, are our statesmen so delicate in their interference or non-interference in the internal affairs of Dahomey? Oude was swallowed at a single mouthful, as an inconvenient neighbour in India; and Japan and China were pierced to the very centre to compel their peoples to listen to the voice of European civilization and open their ports to western trade. Why are our French allies so characteristically polite towards the slave-dealing King of Dahomey, whilst the rulers of Mexico are made to flee before their victorious arms, to avenge the injured honour of France, and to compel redress for the private grievances of her subjects? The reply is a simple one, and is furnished to us by our neighbours themselves—"*Le jeu ne vaut pas la chandelle.*"

Ministers may bestow a few hundreds of pounds upon such a cause, and may compensate for the small expenditure of funds by a lavish supply of letters of introduction; but is it worth while, they ask themselves, to make war for an idea—the suppression of the slave-trade—when the material result will be an improved supply of ivory or palm oil, or a small addition to our importation of cotton wool?

Were the supply of tea (or the demand for opium) likely to be affected, or if some great semi-civilized nation were to be coerced into buying cotton-cloths, then no sacrifice of men or money would be considered too great until the desired end was attained; but, in the meanwhile, Zoological and Geographical Societies and private individuals are compelled to support enterprising adventurers in their efforts to reclaim the waste places of the earth, whilst statesmen hold aloof until the bold pioneer has broken a gap in the hedge, perhaps at the

* From whom an interesting communication will be found in the present number.

cost of his life, and then they follow slowly and cautiously to plant the national standard.

Some day it may be found politic for Governments to take the initiative in such matters, and meanwhile exploring expeditions fitted out by Societies, and the attempts of isolated travellers, such as those who have penetrated into Africa, Australia, and South America, will find a prominent and well-merited place in these pages, and we shall always be ready to afford them our best aid in their efforts to contribute to our geographical knowledge.

As we pass upwards from earth to air, we still find courageous adventurers at work in the cause of Science. Here, too, they are steadily occupied in the task of tracing the operation of Nature's laws under what we consider abnormal conditions, and, by positive evidence, supplanting the calculations of experimental meteorologists whose feet have never left the solid ground.

On these subjects our great atmospheric explorer, Mr. Glaisher, has accumulated a fund of trustworthy information. He has shown that, with an increased altitude, we have not always proportionally diminished temperature, but that the latter is sometimes abnormal to the extent of from one to twenty degrees, during the ascent; that the most rapid decline takes place after leaving the earth, and that the rate of diminution is less in proportion to the increased altitude. The laws of hygrometric variation, too, he has studied and defined more clearly; and, not content with purely physical observations, he has contributed psychological facts of great interest. It would appear from his experience that at great heights every sense becomes more active, and that impressions there formed are more firmly fixed upon the mind than those received below. No doubt the novelty of the situation has a great deal to do with this phenomenon, but altered physical conditions probably exercise a powerful influence upon the nervous system and the mind.

For the benefit of those who brand men of science as infidels, and rail at the "intellectual pride" which, they say, causes them to substitute their own knowledge for the truths of religion, we will quote a few sentences from a discourse of Mr. Glaisher, on the religious influence exercised upon him by his aërial flights, and we hope they may have the effect of removing the false impression as to a want of reverence in scientific men:—"I have experienced the sense of awe and sublimity myself, and have heard it on all sides from aëronauts, who have both written and said the same. For my own part, I am an overwrought, hard-working man, used to making observations and eliminating results, in no way given to be poetical, and devoted to the immediate interest of my pursuit, and yet this feeling has overcome me in all its power. I believe it to be the intellectual yearning after the knowledge of the Creator, and an involuntary faith acknowledging the immortality of the soul."

In Meteorology there are many new features which might afford themes for passing thoughts. The students of Physical Science are directing their attention to the consideration of the nature of fogs upon our coast, and an eminent observer* has discovered that they are either confined to a very limited area, or reach from one to two hundred miles, whilst none have been observed intermediate between these in extent. Nothing definite is known as to their immediate cause. The observations of Admiral Fitzroy upon the course of wind-currents might further detain us, but we cannot tarry any longer in the atmosphere, and must pass, if but for an instant, beyond its limits into the infinite universe, in order to direct attention to one or two features in Astronomical Science indicative of the character of our future inquiries.

No subject has of late attracted more attention than the application of Photography and of Spectrum Analysis to the examination of the heavenly bodies. The labours of Mr. Warren de la Rue in the first-named subject are too well known to require comment; and although the latter application of physical knowledge is yet in its infancy, it has already made us acquainted with some of the constituent materials of the sun, moon, and a few of the fixed stars.

But if the advances made in Chemistry and Physics have placed the heavenly bodies within the reach of experimental and analytical treatment, pure Inductive Science is not on that account the less active in the heavens. Only recently it has been busy in our solar system, upon whose subordinate members new light is likely to be thrown by a careful observation of the so-called "spots" upon the sun's surface. Here, too, the photographic art has been enlisted to perpetuate and confirm the results of astronomical observation. An able astronomer† has arrived at the conclusion, that there is a connection between the "behaviour" of the sun's spots and the configuration and relative position of the planets, and has photographed those "spots," for the purposes of comparison and inference.

Such experiments as these, and all other matters relating to the progress of Astronomy, as well as to the improvement in the fabrication of philosophical instruments already in use, or the introduction of new ones, will meet with a due share of our attention; and it is only necessary to refer to the recent introduction of Time-balls, and Time-

* Dr. Gladstone. † Mr. Stewart, of Kew.

guns, and to their employment in such places as London, Edinburgh, Liverpool, Newcastle, &c., to show how practical is the value of this branch of Science, and how immediately it affects the comfort and safety of the community.*

And having now descended once more to the earth's surface and directed our thoughts to man and his surroundings, it is necessary that we should devote a few pages to the consideration of those subjects which are more immediately connected with his interests, and which affect his own character and condition; and with this view we shall cast a glance at the Natural History Sciences.

One of the most interesting, and certainly the most practically useful subjects to which we can direct attention, is the transport and acclimatization of plants and animals.

We have but to refer to the transplantation of the Quinine-yielding Chinchona-tree from South America to India, and its successful cultivation there; to the introduction of British fruits into the Australian colonies; and to the effort, hitherto but partially successful, to transport British salmon into those colonies for breeding purposes; in order to show what a practical and important movement is here taking place, and how much the influence of pure Science is apt to be underrated, until its material applications become manifest.

The rapidly increasing demand for quinine was likely soon to have materially exceeded the supply from South America, but the success which has attended the acclimatization of the plant in India has removed all apprehension on that head; and the benefits to be derived from the new industry are rendered more certain and immediate by the fact that the young tree yields even a larger supply of quinine than it does in the more advanced stages of its growth.

The scheme of transporting salmon to Australia has not been so successful as the foregoing experiment, but as we feel sure that the labours of the enterprising acclimatizers will ultimately be crowned with success, and will yield a rich harvest to the inhabitants of the Australian continent, and, we trust, to the initiators themselves, we shall devote a page to the narrative of their efforts, and hope that a little influential assistance may thereby be enlisted in their cause.

We would first observe, that there are few features in the history of acclimatization so satisfactory as the success which has attended the introduction of the natural products of Great Britain into Australia. Those who visited the Exhibition of 1862 cannot fail to recollect the

* It is but just to mention, in connection with this topic, the names of Mr. Hartnup, of Liverpool, and Professor P. Smyth, of Edinburgh, to whom the scientific world (and more especially the maritime community) is indebted for many improvements in these instruments and appliances.

wax models of the acclimatized fruits of that continent. The full ears of wheat, the long silky locks of wool, and the long-stapled cotton (the latter introduced into Queensland from various quarters of the Old and New World), must be equally well remembered by all who visited the Colonial Courts.

And now we come to the novel, and not less useful, salmon-breeding experiments. This enterprise was commenced as far back as 1852, we believe, under the auspices of Sir George Grey, of whose efforts to improve the natural productions of the colonies placed under his charge it is hardly possible to speak in sufficiently laudatory terms.

The first experiment failed completely, notwithstanding that fifty thousand ova of salmon and trout were procured and employed in the attempt; and that every precaution was taken to ensure their successful transport. The failure is attributed chiefly to the absence of a continuous stream of water through the hatching apparatus.

For eight years the matter was allowed to rest, no fresh action being taken, but in 1860 a second expedition was fitted out with the same object. Owing to the failure of the precautions which were taken to resist the high temperature of the tropics, and other causes, this attempt was equally unfortunate, and entailed upon a few private individuals a loss of 650*l.* The colonial governments now joined in the enterprise; that of Tasmania, in conjunction with two other legislatures, voting an aggregate sum of 3,700*l.* for a third effort. Careful preliminary experiments were tried in England by scientific men, and vessels were then fitted out specially for the transport of the ova, an apparatus being provided for securing a constant flow of water, as well as for the maintenance of a suitable temperature.

Again, however, the attempt was unsuccessful; the failure in this instance being attributed chiefly to the disturbance of the water in which the young fry, hatched during the voyage, were contained, caused by the violent rocking of the ship. The young fish were dashed against the sides of the apparatus and destroyed. It will not be long, however, before another effort is made to accomplish the desired end, and it is believed that the experience so dearly purchased, will render the next attempt successful. There will be no difficulty, it is thought, in eventually perpetuating the breed of salmon in the antipodes, more especially in Van Diemen's Land, where the rivers already contain a variety of trout; but it is considered doubtful whether this can be extended to New Zealand, where the streams are rapid, and subject to violent floods.

Having thus noticed some of the strictly practical applications of the science, we cannot pass away from the question of acclimatization without referring to the interesting experiment which has been so successfully carried out by our neighbours across the Channel.

The "Jardin d'Acclimatation" may be considered an ornamental and an educational, as well as a practical undertaking; and the admirable combination of art and nature, displaying as it does, in the highest degree, the characteristic taste of the French people, is eminently deserving of commendation. We trust that the time is not far distant when the inhabitants and visitors in the metropolis will have an opportunity of participating in as great a pleasure as that which may now be enjoyed by visitors to the French capital.

All questions regarding man's origin, or his relations to the lower animals, and concerning the connection or differences between the various races of mankind, will receive the earliest consideration of the writers in this Journal. They are *par excellence* topics of the day, and will probably long remain so; and should any of our readers regard them as mere matters of speculation, interesting only to naturalists, or doubt their practical bearing upon society, we recommend them to read the report of the discussion which took place concerning the Negro, at the Newcastle Meeting of the British Association.

At the close of a paper on "The Physical and Mental Character of the Negro," its author, Dr. Hunt, the President of the Anthropological Society, summed up his views as follows:—

"1st. That there is as good reason for classifying the Negro as a distinct species from the European, as there is for making the ass a distinct species from the zebra. 2nd. That the Negro is inferior, intellectually, to the European. 3rd. That the analogies are far more numerous between the Negro and apes, than between the European and apes."

"No man," he continued, "who thoroughly investigates with an unbiassed mind, can doubt that the Negro belongs to a distinct type of Man to the European. This word species, in the present state of science, is not satisfactory; but we may safely say that there is in the Negro that assemblage of evidence which would *ipso facto* induce an unbiassed observer to make the European and Negro two distinct types of man. My second and third proposition must be equally patent to all who have examined the facts."

And there appears to have been great unanimity in the opinions held by the officers of this nascent society, for, in the subsequent discussion, its secretary declared, in confirmation of the views of his chief, that wherever intellectual superiority exists in a man of colour, he is always found to have an admixture of white blood in his veins. In the section in which these statements were made (the Geographical and Ethnological), there were unfortunately but few physiologists present; and the warmest defender of the poor Negro was a gentleman of colour, whose remarks had a moral rather than a scientific bearing. It is possible that there may since have been a fair discussion on the subject which has escaped our notice; but be this as it may, there is no reason why the question should not be fully debated in these pages; and it appears to us that the discussion should be based not upon what is "not satisfactory" in the present state of science, but upon its acknowledged truths.

For ourselves, we do not hesitate to say that we completely differ from much that is contained in the foregoing doctrines, and that they appear to us to be at variance with the opinions and evidence of the most advanced physiologists. If the term "species" be unsatisfactory, we apprehend that its definition has not been rendered clearer by those who state that there is as good reason for placing the black and white man in distinct species, as there is for classifying the ass and zebra in the same manner, ignoring the question of hybridity; but, on the other hand, the admission that an intercrossing of the white and black races has a tendency to develope the intellectual faculties of the latter, and elevate the Negro to the level of the white man, seems to us to be pretty strong evidence that both belong to the same species, and partake of the same nature.

One of the local journals (which by the way reported the proceedings of the Association in a manner that has called forth the admiration of the scientific world*) did not hesitate to hint broadly, that the gentlemen who thus sought to degrade the Negro race, were the tools of the Southern Confederacy, and had been enlisted as the champions of slavery in England.

With regard to man's relations to the lower animals, and his nature and condition prior to the historic era, the opinions of some physiologists are becoming more and more divergent from the views hitherto entertained by the community; and stepping past the most extreme palæontologists of our day in this respect, a new and apparently careful thinker does not hesitate to present himself to the scientific world, and declare that he believes the fossil human remains which were found about six years since in the Neanderthal, near Elberfield, to have constituted the framework of a being endowed with no psychical powers beyond those which would enable it to provide its food and shelter, and possessing neither intellectual nor religious attributes.†

From the consideration of the highest born creature to that of the "Monad," is but a step in the unity of animal life, and the question

* The 'Newcastle Chronicle.'

† See the Report of Professor King's paper read before the British Association, and his article, in the present number, on the Neanderthal Man.

of the origin of man now stands side by side with that of the lowest living types of existence. An eminent physiologist of our day has hinted that it may be possible, before half a century has elapsed, for a man to take inorganic substances such as carbonic acid, ammonia, water and salines, "and be able to build them up into protein matter," and that that protein matter should "begin to live in an organic form." * On the other hand a French geologist of note has in a most solemn manner protested against the presumption of the man who seeks in his laboratory to compete with the Creator! † Both these writers are disbelievers in the theory of "spontaneous generation," and it is in the treatment of this question that they have expressed such opposite views. Whilst we must admit that at present we have grave doubts of Man being able to accomplish such a feat as is here described within the prescribed period, if at all, we confess that we regard without the slightest religious apprehension, any experiments that may be undertaken with this object. The stronghold of life appears to be as safe as it ever has been, and most assuredly, all that man can learn or effect, he is not only justified, but is bound by the gift of an intelligence second only to the Divine Intelligence, to attempt; and if, through his chemical, physical, and microscopical attainments, he should one day become a maker (a Creator he never can become) of living forms, it will only serve as an additional evidence of his vast destiny; and of the boundless powers and infinite wisdom of Him who can thus afford to reveal His secret places in nature to the inquiring gaze of Man. But at present the evidence which we possess on the subject, although of a negative character, is rather adverse to the doctrine of "heterogenesis"‡ in any form. A few words will suffice to explain the actual state of the inquiry.

At present there are three modes by which it is either known or suspected that living beings may be produced.

First, by "Spontaneous generation." That is to say, by the spontaneous combination of decaying organic matters, under certain conditions, and according to an unknown law, to form anew living, moving beings of the lowest known types.

Secondly (an allied form of heterogenesis), by the hand of man. That is to say, through the artificial application of physical or chemical forces and agencies to inorganic substances in the laboratory.

Thirdly, through the operation of the parental law only. In this case the ordinance must have ceased to exist, under which the lower

* Professor Huxley, 'Lectures to Working Men.'

† M. Boucher de Perthes, "Avons-nous Père et Mère?" (This is not said in reference to any particular observer.)

‡ "Heterogenesis" is a term employed to express the creation or birth of living beings in an abnormal manner.

forms of matter were originally combined to form a living being, and the sexual law substituted; one or two pre-existing germs, either active or in a state of rest, being needful for the production of a new being.

But, lastly, it is *possible* that *all* the foregoing laws may be in operation, inasmuch as no one of them necessarily interferes with another.

The evidence in favour of the doctrine of spontaneous generation, is found in the appearance of certain obscure moving types, of infinitely small proportions, in decaying substances, notwithstanding every effort on the part of man to exclude the germs of life in any form. That in favour of the artificial production, by man, of the lowest living types, is of a still more dubious character. It consists in the fact that out of inorganic substances he has been able to make a few organic compounds, such as urea, butyric acid, &c.; but our readers will see clearly that to make an *inanimate* complex substance from other inanimate simple substances, though we may call the former "organic" (in consequence of their usual origin), and the latter "inorganic," is a process widely different from that of making a living, moving, sentient being. Still the latter is not impossible, and if man do succeed in making such a being, and it be endowed with animation by the Giver of Life, he will but have added to his responsibilities, as he every day multiplies them, by the acquisition of fresh knowledge.

But having thus granted a fair hearing to the advocates of the "spontaneous generation" theory, and to those who propound the second doctrine, we feel bound to state that the evidence against both multiplies day by day. It is found, first, in the constantly accumulating proofs in favour of the parental law. One after another, types which were supposed to have been spontaneously generated, from insects down to infusoria, are found to exist as germs or ova, either in the water, in other living beings, in decaying bodies or animal substances, or, as it has been recently shown by French and English observers, to an enormous extent in the atmosphere which we breathe. It has been proved, too, that the tenacity of life which these germs possess is very great; enabling them to defy the hand of time or the destructive power of chemical and physical agencies, and these facts, coupled with the abnormal conditions under which such germs are able to exist after the resuscitation of life, will probably, for some time, defy the attempts of even the most careful and conscientious experimentalists to define satisfactorily under what circumstances the lowest known types first spring into existence.

But we must now take our departure from the field of natural history, and return once more to the consideration of those topics which more immediately affect the progress of civilization; and in order to enable us to do so, we shall be compelled for the present to pass over many questions of interest in chemical and physical science.*

Amongst these are the discoveries of new metals, such as thallium, indium, &c., by spectrum analysis; researches in organic and inorganic chemistry by eminent English and foreign experimentalists, and the important and interesting experiments upon the nature of heat, by our own physicist, Professor Tyndall, as well as all those medical and chirurgical discoveries which have added to the duration of human life or alleviated physical pain; and we shall now refer cursorily to a few features in the progress of Mechanical Science.

It must often appear marvellous to the uninitiated, that the hand of man is able to accomplish works in civil or military engineering, in comparison with which the labours of Vulcan appear puerile and insignificant. But there is one instrument alone, which, since the introduction of steam, has afforded almost unlimited facilities for the employment and fabrication of the coarser metals; we refer to the steam hammer. When this tool was first introduced, about twenty or twenty-five years since, the weight of the hammer was about five hundredweight, whilst that of the instruments now employed in the forging of guns, large shafts, and similar descriptions of work, in some cases attains to forty tons. And it is even stated that there is now one in course of construction at Sheffield, intended for the forging of armour-plates, of nearly one hundred tons. The rapid development of this almost superhuman power, then, is alone able to account for the tremendous results obtained from modern implements of warfare, and for the obstinacy with which these are resisted by modern armour.

But it is not only in its gigantic features that mechanical science is making such rapid strides. The various woods which served the purposes of our forefathers are, indeed, still largely employed, but they are no longer fashioned by the hand of man. Steam and machinery now perform every kind of work with greater accuracy and economy than did formerly muscle and bone, and we have our mechanism for sawing, planing, grooving, tongueing, carving, and indeed for every similar operation.

And through the observations and experiments of men, eminent in physical science, we may calculate upon a greatly increased efficiency of the motive power and its application to almost every kind of manufacturing industry.

Steam, to which in the eyes of most of our readers nothing

* A full *résumé* of the progress of these branches of science will, however, be found in our 'Chronicles.'

can well be added, is itself susceptible, popularly speaking, of a further development, and what is known amongst engineers as superheating, is now daily acquiring a greater amount of favour. The process and its effect are simple and easily understood.

In its passage from the boiler to the cylinder, where its work has to be performed, the steam loses a certain amount of heat; in other words, a portion of it becomes condensed into water; and in addition to this, a certain proportion of partially vaporized water passes from the body of that liquid in the boiler along with the current of steam into the cylinder. The steam thus deteriorated is, according to the more recent plan, "superheated" in its passage, the result being an improvement in its quality: for owing to its more perfect vaporization and its increased temperature on its arrival in the cylinder, it possesses more elasticity, and necessarily a greater impelling power. The superheating process is performed by allowing the steam to pass through an apparatus of tubes, around which the flame or heated gases and atmospheric air circulate in their passage from the boiler to the chimney, thus converting the water-charged steam into elastic vapour, or what is technically called dry steam; and utilizing an amount of heat which would otherwise have been wasted.

Another equally simple, useful, and interesting improvement in engineering science, is "surface condensing." The ultimate effect is the same as that of the foregoing process, namely, an acquisition of power without any additional expenditure of fuel. No doubt our readers will have frequently observed a jet of steam passing into the sea from the hulls of steam-vessels. This is the partially condensed steam, after it has done its work in the cylinder; and in order to supply its place, a fresh stream of cold sea-water is admitted into the boiler. The object of surface-condensing is to save the steam by converting it into warm water and returning it to the boiler. The apparatus somewhat resembles the last-named; but cold water for condensing takes the place of steam for superheating. Instead of the cold sea-water passing into the condenser, there to be *mixed* with the steam and pumped off again along with it, the steam alone passes through tubes in the condenser, and around these, there flows a current of cold sea-water, which is subsequently pumped out, without having come in direct contact with the steam. The latter is returned into the boiler, and thus, instead of cold water charged with saline matter, that vessel is supplied with distilled water at a temperature of 100° to 120°. The foregoing observations apply to the condensation of waste steam from the ordinary low-pressure engine, but a still further improvement has been added, inasmuch as the steam usually ejected into the atmosphere from the high-pressure engine is now conducted into the vacuum in the cylinder of a low-pressure engine, working in conjunction with the former, and thence through the surface-condensing apparatus back into the boiler in the form of heated distilled water, thus practically working two distinct engines.*

These are but two of the improvements which have been introduced into a single branch of mechanical science, and if our space allowed it, we might touch upon many others in its various sections. We could speak of the advances in railway travelling, especially over short distances, and underground, instancing the Metropolitan Railway, with its convenient carriages, excellent system of lighting and signalling, and consequently the comparative safety with which the trains pass to and fro. We might refer to the introduction of coal-cutting machinery,† which will, we trust, one of these days, put an end to the destruction of human beings under the most terrible circumstances that can be conceived; to the improvements in machinery for the utilization of hitherto waste products, and new substances, and which along with others already named, could not in their turn be accomplished but for the employment of improved forms of iron, such as the cheaper steels and semi-steels, homogeneous metal, malleable cast-iron, &c.; but our readers must be content with these passing remarks on the progress of Mechanical Science, and pass on with us to the last subject which demands our notice, and without which our work would be far from complete.

We now refer, not to any special branch of science or human industry, but to the progress of scientific education, and that chiefly in our own country.

Whether this be effected by means of Philosophical Institutions for the middle and higher classes; in the University Lecture Hall for students, or through the machinery of the Science and Art Department of the State; it is entitled to, and will receive, our earnest consideration; and as far as the nature of our work admits, a warm support will be accorded to Science instructors of every rank and station; indeed it will be our earnest desire, however limited may be our influence, to promote the welfare of all scientific men, from the most illustrious observer, to the humblest labourer in the fields of Science.

And now, conscious that in this extended but hasty survey, we must have said much that is open to doubt and criticism, and left unsaid

* Of the two steamers 'Hibernian' and 'Bohemian,' both of which are about the same tonnage, plying between Liverpool and Canada, the former is fitted with a surface-condenser, but not the latter. The former consumes 44 tons of coals per day, and makes 12½ knots per hour; the latter requires 55 tons per day, and steams only 11 knots per hour.

† Concerning which, some valuable information will be found in the present number of our Journal.

many things which readier pens or abler minds would have treated with accuracy and clearness, we have a few parting words to add to our readers, and more especially to a large class to whom we look for considerable support, and who may do much to facilitate our labours; we mean ministers of religion.

It would avail us little, if, after intimating, as we have done in the preceding pages, that the social, and even the political bearings of Science will not be overlooked, we were to remain silent on the great question of Theology. To do this, would be simply to arouse suspicion, and lead to misconstructions which a frank exposition of our views may obviate: and we have less hesitation in approaching so delicate a question, from the conviction that however adverse may be the views of individuals, or even, here and there, of some body of narrow-minded theologians, a vast majority of our religious teachers look with anxiety, and without apprehension, upon each new revelation of the laws of nature, and watch with interest its bearings upon theological inquiry. Scientific knowledge will never lower man's religious nature, nor render it any less devotional, unless it be employed for worldly purposes, or perverted to private ends by the promptings of passion. Sound Science must make *some* enemies, for, as we have already said, it drives superstition before it, as chaff is driven before the wind, and it may answer this or that prophet of our day to sneer at its propounders as self-righteous, or to hold them up to scorn as infidels; but every sincere and devoted preacher of the Truth, knows it to be not only to his interest, but that it is indispensable that he should be acquainted with other branches of knowledge than those immediately connected with his vocation, and that he should at least march abreast with, if not precede, the foremost rank of lay intelligence. That many such inquiring men will be amongst our readers, as they may already be found amongst our contributors, we have no doubt whatever, and the question arises, how shall we deal with such subjects as are supposed to have a more or less direct bearing upon Theology?

There need be no hesitation in furnishing the reply.

It would ill serve the ends of truth in any form, if we were to interfere with the free discussion of scientific topics on the ground that the views enunciated might give offence to the believers in some particular theological doctrine. Such a course would defeat rather than promote the ends of true religion, and it may even be necessary that we should now and then be tolerant of the expressions of what may appear erroneous or extreme views, for the purpose of ultimately eliminating the truth. Whilst, however, we have too much faith in the good taste and right feeling of our collaborateurs to suppose that freedom of discussion would ever be employed as a cloak for irreverence, we are bound to state that it will not be with our cognizance or sanction, if any expression in the slightest degree savouring of this quality finds its way into our Journal; and we add this, not to curry favour with those to whom these remarks are more particularly addressed, but in order that persons who are anxious to consult these pages with a view to the acquisition of sound science for the purposes of religious teaching, may not be driven away, to make place for others of a less friendly disposition, whose aim will be to detect heresy, or to turn the revelations of nature into a means of upholding superstition.

The cause of science may be advocated on the ground that it tends to the comfort and material prosperity of the human race; or because it serves to elevate man's intellect, and to enable him better to fulfil his brief mission on Earth; but its highest title to a foremost place in the literature and teachings of the day is found, not in either of these advantages, but in the fact that by disciplining the minds of men it imparts to them a purer and more elevated conception of the Creator, and prepares them for the comprehension of the highest truths, thus helping to fit them for a purely spiritual existence.

ORIGINAL ARTICLES.

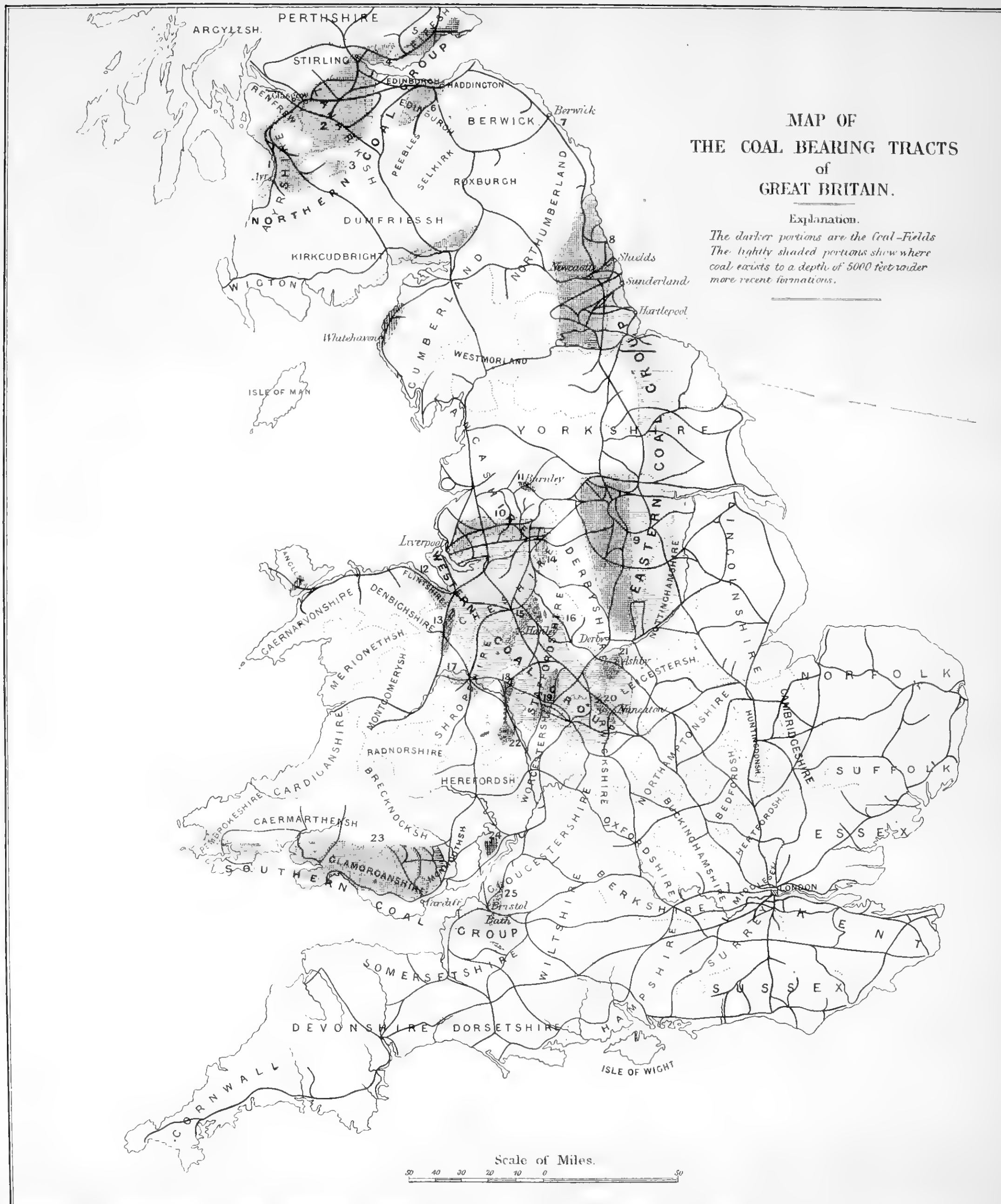
THE COAL RESOURCES OF GREAT BRITAIN.

By Edward Hull, B.A, F.G.S., of the Geological Survey of Great Britain.

Of all sciences, none, perhaps, is so generally regarded as devoid of practical application as Geology. The employment of Astronomy in Navigation is known to all; the numberless uses of Chemistry in the Arts are self-evident; Mineralogy is, of course, of value in detecting minerals; Physics, in laying down the principles of the electric telegraph, and Mechanics, in the construction of machinery. But Geology! "what *can* be the use of Geology?" asks the world. If you answer that it has served to throw a flood of light on the past history of our globe, such a reply will not satisfy the utilitarian; and the "practical" miner will say (though erroneously) that he can work his way in the earth in search of the minerals as well without, as with, a knowledge of Geology. To all such inquiries, as to the practical use of this science, let me proceed to give a final answer. Premising that Geology is capable of application in the elucidation of a number of questions affecting our every-day life, which cannot be dwelt upon here, I may state that it is pre-eminently useful, and indispensable in enabling us to estimate the extent of those stores of mineral fuel which Providence has laid up in the strata of the earth for the service of man.

The coal stored up in the bowels of the earth is limited in quantity, and, like the Sibylline Books, when once burnt, is irrecoverable; every day sees this store diminished; and just as the master of a house, at the approach of winter, wishes to ascertain the quantity of fuel in his cellar, so must it be a subject of moment to us as a nation—depending as we do so largely on the supply of coal for our manufacturing, commercial, and even political, pre-eminence,—to ascertain as far as possible, to what extent we may reckon on the continuance of this great source of motive power. Without the aid of the science of Geology, such an inquiry could only have ended in disappointment; with it we have all the materials necessary for the solution of the problem, as far at least as regards the actual quantity of coal itself.

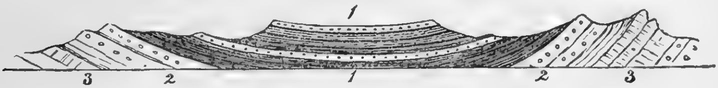
The strata, or "measures," containing the beds of coal, belong, for the most part, to the great Carboniferous System of Rocks. They occur generally under two modes of arrangement; either as "basins"



Stanford's Geograph. Establishm. London

or "fields:" and on the threshold of our inquiry it may be well to give a short sketch of each of these systems.

FIG. 1.—*Section of the Forest of Dean Coal-Basin.*



1. Coal-Measures. 2. Millstone Grit. 3. Mountain Limestone.

Coal-basin.—The section of a coal-basin is represented in the above woodcut. The term is used when the beds dip from every part of the circumference towards the centre. When the basin is elongated in one direction to a considerable degree, it is called a "trough;" but as it is rare for any coal-bearing tract to be even approximately symmetrical, the term "basin" serves to denote all such tracts, whether the outline be circular or oval. To this form belongs the largest coal-tract in Britain—the South Wales Coal-field (No. 23 in Map), as also that of the Forest of Dean (24), and several others.

FIG. 2.—*Section of the Yorkshire Coal-Field.*

1. Magnesian Limestone. 2. Permian Sandstone. 3. Coal-Measures. 4. Millstone Grit. 5. Limestone Shale. 6. Mountain Limestone.

Coal-field.—In the case of a coal-field, the strata dip (with more or less regularity) in one direction. Such an arrangement has many modifications; either the strata dip under those of a more recent formation, as in the case of the Yorkshire Coal-field (Fig. 2), or they are cut off along one side by a fault, as in the Anglesea coal-field. This is the more general form which a coal-tract assumes, and is often much varied by rolls in the strata, or by dislocations.

Coal-group.—Where the strata of several coal-fields dip towards each other, and under those of a newer formation, such as the New Red Sandstone, it may generally be inferred that they are connected underneath, and that if the newer formation were penetrated, the coal-measures could be reached beneath. When several of these coal-fields are thus physically connected, they give rise to what may be called "a group of coal-fields," or simply a "coal-group." Under the same title we also place a number of distinct *basins* or *fields*, which were originally connected, but have since been dissevered by denudation, as those of the central valley of Scotland. In this manner the British coal-areas naturally arrange themselves into four groups, which, on the map, have been marked as the Northern, Western, Eastern, and Southern coal-groups. These great divisions refer more immediately to the *present* arrangement of the tracts than to that which they assumed at the time of their formation. Nevertheless there is reason to believe that out of the four only two were originally continuous with one another, namely, the eastern and western groups. From this great sheet of coal-bearing strata which once stretched right across our island from sea to sea, and even farther, the northern and the southern coal-groups were both separated, the latter by a barrier of land, the former by difference of age; for we now know that coal was in process of formation in Scotland while the Carboniferous limestone was accumulating in the sea-bed over the English area. The following are the subdivisions or fields of the several groups.

Northern Coal-group of Scotland.*

Comprehending—1, the Coal-fields of Ayrshire; 2, Clyde basin; 3, Lesmahago basin; 4, Clackmannan; 5, Fifeshire; 6, The Lothians.

Eastern Group (*England*).

8, Great Northern Coal-field of Northumberland and Durham; 9, Derbyshire, Yorkshire, and Notts (only one coal-field).

Western Group (*England and Wales*).

10, Lancashire; 11, Burnley basin; 12, Flintshire; 13, Denbighshire; 14, Poynton; 15, North Staffordshire; 16, Cheadle; 17, Shrewsbury; 18, Colebrook Dale; 19, South Staffordshire; 20, Warwickshire; 21, Leicestershire; 22, Forest of Wyre.

Southern Group (*England and Wales*).

23, Forest of Dean basin; 24, Somersetshire; 25, South Wales basin. Besides the above enumerated, there are several small detached fields, such as those of the Border, on the north side of the Solway Firth, Whitehaven, and Anglesea.

The two great coal-fields of the Eastern group are, in all probability, connected by a tract of coal-measures underlying the Triassic and Permian formations along the east of Yorkshire, as indicated by the shading on the map. The numerous fields of the Western group are, without doubt, physically connected underneath the New Red Sandstone of Cheshire and Staffordshire; and, as already stated, those of the Southern group were, in their original state, joined together.

Having thus cleared the way by a survey of the general structure and arrangement of the coal-groups, we are now prepared to enter upon an examination of the resources of the more important of the fields and basins.

Northern Coal-group.

Having already enumerated the members of this group, we must content ourselves with treating them as a whole, because, with the exception of two or three distinct fields, such as that of the Lothians, Fife, and Lesmahago, the coal-bearing rocks of Scotland are all physically connected, and the structure of each is too complicated to allow of treating them in detail within the space at my disposal.

The coal-formation of Scotland belongs, for the most, to the

* The numbers refer to those on the Map.

lower Carboniferous series, and is therefore of greater antiquity than that of England. It occupies the broad valley stretching from the Firth of Forth to the Firth of Clyde, and is bounded on the north by the frontiers of the Highlands, and on the south, by the hilly and wild tract which gives birth to the sources of the Tweed. The coal-seams are often interrupted by the intrusion of igneous rocks, and in some places, the older Carboniferous and Devonian formations rise to the surface, and terminate the continuity of the beds. There is documentary evidence to show that coal was worked in Scotland from at least the fourteenth century,* and the Celtic name for the mineral is still preserved in that of a little tarn, called Lough Glo. The total area of workable coal equals 1,720 square miles, and the total available supply of coal to a depth of 4,000 feet, amounts to 25,300 millions of tons.† The quantity raised in 1861, was 11,081,000 tons from 424 collieries.‡ In this is included the double coal-trough of the Lothians —the resources of which were calculated with much labour by Mr. Milne-Hulme and Mr. S. Nicol, several years ago. It will be seen from the above estimates, that there is coal enough to last at the present rate of consumption for about 2,000 years.

Eastern Coal-group.

The Great Northern Coal-field.—The resources of this district have been more fully illustrated than those of any other coal-field in England. No less than six distinct estimates having been made, and they all come to very nearly the same conclusion regarding the available quantity of coal at the time specified by each.

The coal-field extends from the mouth of the Coquet, on the north, to that of the Tyne on the south, a distance of fifty miles. The strata dip generally eastward, and are ultimately concealed beneath the table-land of the Magnesian Limestone, which is now penetrated by shafts in search of the subordinate coal-beds. The actual coal-field has an area of 460 square miles, but to this we must add the area overspread by the Magnesian Limestone, and other formations of more recent age—that is, 225 square miles—making in all 685 miles, and containing about 7,200 millions of tons of available coal. This coal-field has from the infancy of mining been one of the greatest producers; and from its store the Metropolis of the Empire has principally been supplied. The consumption is still steadily increasing,

* Ænei Sylvii Opera, p. 443.

† 'Coal-fields of Great Britain,' 2nd edit., p. 179. I must here apologize to the reader for quoting myself, which I do for the simple reason that there is no other authority extant for the resources of all the British Coal-fields, though there are for a few special ones which shall be stated. The calculations contained in my work were made with much care, and have been used by Sir W. Armstrong, President of the British Association. I may here state, in order to avoid the appearance of dogmatism, that in dealing with so large a question as the number of tons of coal in any of our coal-fields, the figures do not pretend to be more than close approximations to the reality, but it would be a useless repetition to place before each group of figures such words as "about," "approximately," "nearly," &c., which the reader is requested mentally to introduce for himself.

‡ Hunt's 'Mineral Statistics of Great Britain' for 1861.

and in 1861 reached 19,144,965 tons. Supposing the amount to reach 20 millions, the supply would last 360 years. The calculation of Mr. T. Y. Hall, in 1854, was 365 years.

Coal-field of Yorkshire, Derbyshire, and Notts.—This is the largest coal-field in England, and extends from Bradford and Leeds on the north, nearly to Derby and Nottingham on the south, a length of sixty miles. Towards the northern outcrop, the strata, which had previously maintained a meridional direction throughout a distance of about fifty miles, suddenly bend round at right-angles, and trending eastward, are ultimately lost beneath the Magnesian Limestone which passes over their edges, and rests on the Millstone Grit. The same beds again re-appear in the northern coal-field, and there is good reason for believing, with Professor Phillips, that these two districts are physically connected beneath the more recent formations, as indicated on the map by the faint shading.

The general dip of the coal-strata is eastward; but there are several rolls or troughs running north and south through the centre of the field. The coal, which is of very fine quality, is known as "splint," from its splintery fractures.

In estimating the resources, a considerable addition must be made to the area of the actual coal-field, for the available coal-ground concealed beneath the Magnesian Limestone and Trias on the east, amounts to probably one-half as much again. The exact distance to which the coal-measures extend in this direction is, of course, at present a matter of conjecture, and will probably never be known, as the overlying strata increase in thickness the further we proceed eastwards; but the distance is certainly considerable. The Permian beds have already been pierced in several places by collieries, one of the most remarkable being that recently sunk on the property of the Duke of Newcastle at Shireoaks, in which the Permian beds were found to be 66 yards in thickness. Taking the area of the coal-field at 760 square miles, and that of the available ground occupied by the Magnesian Limestone at 400, there will thus be 1,160 square miles with coal, an area larger than the coal-basin of South Wales, and only less than that of Scotland. The available quantity of coal will not fall short of 16,800 millions of tons. The quantity raised in 1861 was 14,490,919 tons, so that at this rate of consumption there is sufficient to last for upwards of a thousand years. There were in 1861 about 577 collieries, of which only five passed through the Magnesian Limestone in 1859.*

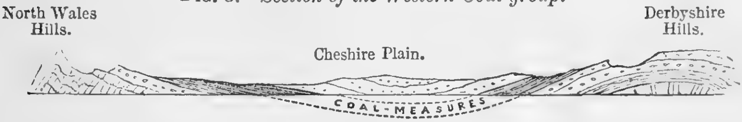
The Western Coal-group.

The Western Coal-Group is bounded on the north by the Lancashire coal-field, on the east by those of North Staffordshire, Leicestershire, and Warwickshire; on the south by those of South Staffordshire and Shropshire, and on the west by those of Denbigh and Flintshire. The strata of these respective coal-fields have a general dip towards the centre of this great basin, which is occupied by Triassic and Per-

* As I am informed by Mr. C. Morton, Her Majesty's Inspector. There may have been a few more since that time.

mian beds, and there can scarcely be a question that the coal-formation extends underneath over the whole area (as represented in the map), though often at very great depths. The following diagram (Fig. 3) will give an idea of the manner in which the Carboniferous beds rise from beneath the newer formations at the eastern and western sides of the basin.

FIG. 3.—*Section of the Western Coal-group.*



The mineral resources of this vast area, which is not less than 4,700 square miles, are practically inexhaustible were it possible to work the coal over the whole of it, but such an idea is altogether visionary, as the overlying formations often attain a thickness of 5,000 feet, which would have to be passed through before reaching the first seam. I shall hereafter endeavour to show that such a depth is probably beyond the reach of mining enterprise, at least with our present mechanical appliances. I therefore pass at once to the consideration of the available portion near the margin.

South Lancashire.—Owing to the great demand for coal arising from the extent of population and manufactures in this country, this coal-field is being heavily taxed. The area of the coal-bearing portion* is 192 square miles. The field extends from Rainford and Prescot on the west to Ashton-under-Lyne on the east, at which place it bends southward into Cheshire, and throws out a small arm as far as Poynton. The general dip of the strata is southward, and the seams descend under the Triassic rocks of Cheshire. Within a vertical limit of 4,000 feet there is an available quantity of coal to the extent of 3,700 millions of tons, and the quantity raised in 1861 was about 12 millions, at which rate of consumption the coal would last for about 300 years.

The Burnley Coal-basin.—This tract lies considerably to the north of the main field. It is in form a half-basin, bounded on the south-east side by a large fault. It has an area of 20 square miles, and a combined thickness of 40 feet of coal. The available quantity is about 270 millions of tons, and the annual yield about one million.

Flintshire and Denbighshire Coal-fields.—These two fields occupy the same general range of hills, rising above the Triassic plains of Cheshire and Salop. The former is rapidly approaching exhaustion, owing to the fact that the seams nowhere descend to any great depth, but are repeatedly brought to the surface by faults; consequently they have been largely worked in the days of shallow pits. At Mostyn, coal is worked under the sea, and attempts have been made to reach the seam beneath the New Red Sandstone. The area of the field is 35 square miles, and there remains for future supply little more than 20 millions of tons, of which the present generation may see the end.

* This is exclusive of the hilly district, in which there are occasional thin seams, known as "mountain mines."

The Denbighshire field, on the other hand, has a somewhat larger area, and holds a very much greater quantity of coal. It occupies about 47 square miles, and has an available store of 490 millions of tons. The seams dip eastward (*see* Fig. 3), under large tracts of Permian and Triassic beds, and were the minerals capable of being followed in the direction of the dip, the supply might be almost indefinitely extended. The quantity raised in 1861 from these two coal-fields, amounted to 1,870,250 tons.

North Staffordshire Coal-field.—Considering its extent, this is one of the richest, and at the same time least developed, coal-fields in Britain. With an area of 75 square miles, a vertical thickness of 5,000 feet of coal-bearing strata, containing 22 valuable seams, as well as several very rich beds of ironstone; there are only a few mines of any great depth, and a considerable portion of the district may be considered virgin ground. At the same time mining operations are being rapidly extended, so that between the years 1857–61, the quantity of coal raised had doubled itself, and in the latter year it reached 2,372,500 tons.

The shape of this coal-field is nearly triangular, with its apex to the north. Towards the south and west the coal measures dip at moderate angles under Permian and Triassic formations, which at no distant day will, in all probability, be invaded by collieries. The available supply of coal for future use is not less than 1,600 millions of tons, which is capable of sustaining the present drain for nearly 700 years.

The Cheadle coal-field is separated from that of North Staffordshire by a ridge of Millstone Grit, and contains only a few of the lower seams. In an economic point of view it is unimportant.

South Staffordshire Coal-field.—This coal-field is remarkable from the fact that it has been upheaved bodily through the Triassic rocks along two lines of dislocation which bound it on the east and west sides. Unlike that just described as in the freshness of youth, this may be considered as having passed the meridian of its career, and as being on the verge of old age. Its extraordinary richness has been the principal cause of its early decline, and the treasures easily acquired have been often recklessly squandered. No district in Britain has been more favoured by nature in the richness of its stores of coal and iron, but unfortunately for their efficient and economical working, they have been placed too near the surface, and consequently have been mined by means of a vast number of small, ill-managed coal-pits, instead of on a well-regulated system of mining, such as is involved in the working of more extensive collieries. In some places the water from the old excavations has been allowed to accumulate to such a degree that large areas are hopelessly drowned out, and in others much of the coal has been wasted. At the same time this mineral wealth has given rise to the concentration of an enormous amount of manufacturing industry, and the spectacle of blast-furnaces, foundries, coal and iron-pits, and houses interlaced by a network of canals, railways, and roads, which the " black country " presents, is familiar to most of our readers.

Over the southern half of the field—that is, south of the Bentley fault—a coal-seam no less than 30 feet thick is, or was, spread. It is called the "Dudley 10-yard seam," and is the thickest in England, if not in Britain. North of the fault it is split up into nine separate seams, which collectively form 30 feet of coal.* The area of the coal-field is 93 square miles, and of the original quantity of 3,000 millions of tons of coal, not more than 960 millions remain. The production of coal has of late years rapidly increased, and in 1861 it reached 7,253,750 tons from 580 collieries. Taking the future production at eight millions of tons, the coal would last 120 years.

Colebrook Dale Coal-field.—This district is even further advanced towards exhaustion than the one we have just considered. The coal has been worked here more than a thousand years, for it was found in the ruins of Uriconium,† and, with the rich seams of ironstone, has laid the foundation of several celebrated iron manufactories. Over the larger part of the field both minerals have been already worked out, and the only place where they yet remain entire is along the eastern edge. The miles of country covered by mounds of slag, and waste heaps of former mines, bear witness, even to the casual passer-by, that the earth has been despoiled of all her treasures.

The area of the field is 28 square miles. The beds dip eastward, and may one day be followed under the Permian and New Red Sandstone; but there are certain irregularities in the stratification of this coal-field, that render it uncertain to what extent the beds of coal underlie the newer formations. Only one-third of the original quantity of workable coal remains, which we may place at 14 millions of tons. In 1861 the quantity raised was 829,750 tons, so that twenty years hence the coal will in all probability be exhausted.

Leicestershire Coal-field—This is a small, but rich district, as it contains one seam 12 or 14 feet in thickness, and several others of value. On the Coleorton, or eastern side, there are several collieries which are situated on the Trias, and it was here, at Whitwick colliery, that George Stephenson, with that power of observation so remarkable in him, first came to the conclusion that the coal-measures dipped under the New Red Sandstone, and then demonstrated the fact by sinking a shaft to the main coal.‡

The area of this field is upwards of 15 square miles, of which a part is concealed by newer formations, with an available supply of 140 millions of tons. The quantity raised in 1861 was 740,000 tons.

Warwickshire Coal-field.—The position of this coal-field is interesting from the fact that it forms the farthest prolongation of the Carboniferous strata towards the south-east of England. It occupies a long and narrow strip of country, stretching from near Tamworth to Wyken, a distance of 15 miles. The strata dip to the south-west under large tracts of the Permian formation, where the coal lies at accessible depths, and will greatly prolong the resources of the district. The

* Mr. J. B. Jukes'. 'Memoir on the North Staffordshire Coal-field,' 2nd edition.
† Or Wroxeter. Mr. T. Wright states that cinders were discovered under several of the hypocausts.
‡ Smiles' 'Life of G Stephenson.'

area of the coal-field is 30 square miles, and the available supply about 400 millions of tons, to which a very large addition must be made for the quantity underlying the Permian formation. In 1861 the produce of this coal-field was only 647,000 tons, which cannot be said to be in due proportion to the resources.

The small and but slightly productive districts of Shrewsbury, the Forest of Wye, and the Clee Hills, do not require special notice here, further than to intimate their existence.

Southern Coal-group.

Forest of Dean Coal-basin.—In structure, this is a more perfect basin than any in Britain, as the strata everywhere dip from the circumference towards the centre (Fig. 1). It is by no means opened up to the extent of its capabilities, and for the most part presents the aspect of rich forest scenery, with only an occasional coal-pit chimney at wide intervals rising in the midst of the trees. Its area is 34 square miles, and it contains about 560 millions of tons of available coal. The annual produce is about 1,000,000 tons, which in a few years will be considerably extended by the introduction of railways now in process of construction.

Bristol and Somersetshire Coal-basin.—The greater portion of this basin is uncomformably overlaid by a newer formation of Trias, through which the coal-measures only appear at intervals; yet its general form has been pretty well ascertained by means of collieries and borings. Including the parts occupied by Red Marl and Lias, the area is not less than 150 square miles, with 51 seams of coal distributed through 5,000 feet of strata. Of these seams, however, only 20 are of a thickness of 2 feet and upwards, and owing to some special physical impediments (such as the presence of the "Pennant Grit"), very large deductions require to be made before arriving at the available supply. This quantity I do not place at a higher figure than 2,000,000,000 tons. The produce for 1861 was 1,025,525 tons.

South Wales Coal-basin.—The greatest of our coal-basins is the last but one to be described. It is truly an astonishing reservoir of mineral fuel, whether we regard it for its actual area, not less than 910 square miles; the enormous thickness of the strata stored with coal, reaching 10,000 feet; the vertical accumulation of coal, stated by one authority to be from 70 to 100 feet in thickness; * or lastly, from the symmetrical form of its outline, which is nearly that of a pear. It is, in fact, an elongated basin or trough in which the strata dip towards the central axis, that axis itself at the same time coinciding with a great upheaval of the strata in the form of a roll or anticlinal. The coal-field is divided into three districts: the west, yielding anthracite; the centre, steam coal; and the east, bituminous coal. The richer beds lie near the bottom, and these are often placed within reach of mining operations by the great depth of the valleys, which penetrate for miles into the central high-lands, laying bare the strata many hundred feet.

* Mr. H. H. Vivian, 'Speech on the Coal Clause,' House of Commons, 1861.

The quantity of *available* coal yet remaining is, according to my own calculations, 24,000,000,000 tons. This is one-half the whole amount originally contained in the basin, a very large portion of which is at a depth below 4,000 and 5,000 feet. The produce of the 313 collieries in 1861 was 6,690,771 tons, which is considerably lower than in previous years, probably from the falling off in the export trade owing to the American war, but even should the amount reach ten millions of tons, there is enough to last 2,400 years, or to supply the whole consumption of Great Britain for about 300 years,—a fact which one might suppose ought to set the mind of the public at rest on the subject of our coal-resources.*

Cumberland Coal-field.—This being detached from any of the above groups, I have reserved for the last. It forms a small band stretching along the sea, from Whitehaven to Maryport, and has been worked from very ancient times, as we have documents showing that the seams had been followed under the sea as early as the beginning of the 18th century. The area of the coal-field is 25 square miles, and the quantity of coal remaining for use is about 90 millions of tons.

The following summary of the above shall conclude this part of the subject.

General Summary. †

Group.	Area, square miles.	Resources in millions of tons.	Produce, 1861.	Number of Collieries.
Northern . . .	1,920	25,300	11,081,000	424
Eastern	1,845	24,000	34,635,884	848
Western . . .	535	7,594	25,643,000	1,158
Southern . . .	1,094	26,560	13,201,796	516
Cumberland . .	25	90	1,255,644	28
	5,419	83,544	85,817,324	2,974

The above figures being rendered into words, mean that there are in Great Britain, within a depth of 4,000 feet from the surface, 83,544,000,000 of tons of coal available, and that this quantity divided by the quantity raised in 1861, say 86,000,000 of tons, would last for about 970 years.

Having thus determined approximately the resources of our coal-fields, and making no pretensions to prophecy, it might be wise, perhaps, to close this article without venturing one word regarding the future. Nothing is more liable to error than prospective statistics; the only person who is privileged to make use of them being the Chancellor of the Exchequer for the time being. At the same time, the falsifi-

* The estimates of Mr. Vivian are much larger than my own; but I think he has fallen into the error of multiplying the average thickness of coal into the full area; whereas the range of some seams is very far short of that.

† The produce and number of colleries are from the 'Mineral Statistics of Great Britain,' for 1861, by R. Hunt, F.R.S., but differently arranged to suit the classification into groups here adopted.

cations to which the estimates of this great functionary are often subject, may well be a warning to all would-be minor prophets not to venture on forbidden ground. We feel it, however, necessary to say a few words in vindication of what may appear the, somewhat arbitrary, limit of depth which we have adopted in the above calculations of our coal-resources. The reader will be justified in inquiring why we prefer 4,000 feet to 5,000 feet on the one hand, or 3,000 on the other, and he is therefore entitled to a reply, though it must be a brief one.

Taking the latter figure first, we may state at once that this depth has already been attained, or very nearly so, in more than one colliery, both in our own country and on the Continent,* and no colliery manager will maintain that the limit has been here reached.

With regard to 5,000 feet as a limit of depth the case is otherwise; for we have reason to conclude that supposing this depth to have been attained, the temperature, not to speak of other obstacles, would be found so high as to forbid the employment of human labour.

The increase of temperature as we penetrate from the surface, is a law which has been established on the evidence of a large number of observations in all parts of the world. In our own country very interesting and careful experiments have been made in several mines; both in the metallic mines of Cornwall, and the coal mines of the North of England.† Having on a previous occasion given the experiments in detail, the results need only be stated here, and are summarized in the following table, together with the temperatures calculated to a depth of 4,000 feet.

Table of Increase of Temperature for Depth.

Depth in feet.	Increase of Temperature due to Depth.	Increase due to Density of Air.	Resulting Temperature.
1,500	21·42	5·0	76·92
2,000	27·85	6·5	84·85
2,500	35·5	8·5	94·00
3,000	42·14	9·83	102·47
3,500	49·28	11·66	111·44
4,000	56·42	13·16	120·08

In the above table "the temperature of no variation" adopted, is 50·5° at a depth of 50 feet from the surface.

From the foregoing tables it will be seen that even at a depth of 4,000 feet, a temperature may be expected more than tropical, though less than it would be at 5,000 feet, and sufficient, we think, to place

* One shaft in Belgium, we are assured, is 932 yards in depth. In Saxony, there is another upwards of 800 yards; and in the Dukinfield Colliery, the black mine has been followed to the depth of 940 yards from the surface.

† Experiments made at Rose Bridge Colliery, Wigan, and Dukinfield Colliery, Ashton-under-Lyne, and detailed at length in the 'Coal-fields of Great Britain,' pp. 223-232. The latter were first published by Mr. W. Hopkins, F.R.S., in the 'Philosophical Transactions,' vol. cxlvii.

the limit of depth within the last-mentioned figure. The means by which the temperature even at 4,000 may be reduced so as to admit of healthful labour is ventilation, and the question remains, to what extent can this be accomplished. A series of interesting experiments undertaken at my request by Mr. Bryham, at Rose Bridge Colliery, Wigan, enables us to arrive at the following general conclusion:—that in a mine of ordinary extent, the temperature can be lowered by 20° or 30°, according to the distance from the shaft, and the season of the year. The cool air of winter reduces the heat of the mine more than that of summer time, so that even with a depth of 4,000 feet it may be often impossible to excavate the coal except during the colder months of the year.

Space will not admit of our doing more than to glance at the past history and future prospects of coal-mining. It may be said that up to the end of the last century, the art had only smouldered. It was when the invention of the steam-engine revolutionized the industry of this country, that mining burst forth with an energy previously unapproached. Probably not more than ten millions of tons of coal were raised at the commencement of this century; yet in 1830 the quantity raised was thirty millions, and in 1851 not less than fifty-four millions.* From 1854 downwards, we have the returns of the Mining Record Office,† which show a general tendency to expansion, though with fluctuations; the maximum having been reached in 1861, when the enormous quantity of eighty-six millions of tons was brought to the surface.

Notwithstanding these facts, however, it would be rash to assume that the experience of the past is to be a criterion of the future. We neither wish for, nor expect, an increase during the remainder of this century at all proportionate to that of the earlier half, and this view is borne out by some of the later returns. Some of our coal-fields, as has been shown, have passed their meridian, and, having expended their strength, are verging on decay. Others have attained their maximum, or nearly so; this indeed is the case with the majority. The younger coal-fields will have much of their strength absorbed in compensating for the falling-off of the older; so that in a few years the whole of our coal-producing districts will reach a stage of activity beyond which they cannot advance, but around which they may oscillate. Entertaining these views, I am inclined to place the possible maximum of production at one hundred millions of tons a year; and yet it has been shown that even with this enormous "output," there is enough coal to last for eight centuries.

* On the authority of Mr. J. Dickinson, Her Majesty's Inspector of Coal Mines.

† 'Mineral Statistics,' 1854-61.

OCEANIC TELEGRAPHY.

I. The Deep-Sea Bed of the Atlantic and its Inhabitants.

By Dr. G. C. Wallich, F.L.S.

The sounding-machine has already conducted us to the confines of an unexplored world. It has enabled us to penetrate the secret so long and so steadfastly concealed by nature beneath the waters of the ocean, by placing within our grasp the still living forms of creatures differing in no material respect from some of those inhabiting moderate depths, yet capable of sustaining existence under the extraordinary conditions known to prevail amidst the more profound abysses of the sea-bed. In short, it has taught us that our preconceived views concerning the incompatibility of these conditions with the performance of functions which are essential to life, are erroneous and demand most careful revision.

The fact, as thus stated, appears simple enough, and may, by many persons, be regarded as involving purely scientific issues. It will be our aim, however, to show that this is by no means the case; and that, whilst the interest attaching to the discovery of animal life under such circumstances is undoubtedly great, and likely to lead to valuable results in every department of Natural History, the practical bearing of this discovery on the question of Oceanic Telegraphy is of no less important a character. But in order to render ourselves intelligible, we must briefly direct attention to what was known on the subject prior to the time when it assumed its present aspect through the discovery of living star-fish procured from a depth of nearly a mile-and-a-half below the surface.

Without stopping to notice the various conjectures regarding the nature of the deep-sea bed, which had previously been hazarded, it may suffice to mention that specimens of the material of which it is composed were, for the first time, systematically obtained about ten years ago. These consisted, for the most part, of an extremely fine mud, with a large proportion of microscopic shells belonging to one of the simplest forms of animal life with which we are acquainted. Some of the shells retained a considerable portion of the gelatinous substance of which the bodies of this class of organisms is composed. But at this point the evidence failed. For whilst the fact of these organisms having been raised from vast depths was too clearly established to admit of the slightest doubt, it is manifest that they might have been drifted from shallow water by oceanic currents, or have lived near the surface of the sea, and gradually subsided to the bottom after death. Accordingly, the mere presence of the gelatinous substance of which their bodies are formed, when taken in connection with the well-known preservative power of sea-water highly charged with saline matter, affords no proof whatever of the creatures having lived in the localities from which they had been conveyed by the sounding-machine. But although the determination of the question as to whether animal life can be sustained at such depths was reserved for a later period, these earlier soundings were not barren of highly important results; for they enabled Professor Ehrenberg, on comparison of the material obtained from the bottom with that entering into the formation of chalk, to announce the extraordinary fact, that this rock is built up, atom by atom, of shells similar to those met with in such profusion along the bed of the ocean; and further, that it must have been deposited under conditions similar to those now prevailing; thereby furnishing the clearest proof that the great forces which were in operation at the sea-bed countless ages ago, are in operation still; and will, in all probability, continue to be so through all time.

We now arrive at the period when the survey of the sea-bed received a fresh and powerful impulse from the project of establishing communication between Europe and America by means of a Telegraphic Cable. With a view to ascertain the general contour and composition of the portion of the Atlantic it was proposed to traverse, an expedition was sent by the Government of the United States, to sound from shore to shore. But unfortunately, the information elicited in the course of this survey was so vitiated by inaccuracies as to have induced the eminent officer, then in charge of the Hydrographic department at Washington, to pronounce it untrustworthy. A second expedition was accordingly equipped, under the auspices of the British Government. Of the accuracy of the depths recorded on this occasion there could be no doubt. But the intervals between the positions at which soundings were taken were so great, and the means of obtaining specimens of the bottom so imperfect, that, looking at the matter as we now do after the event, it seems impossible to regard the information elicited as in any degree adequate to meet the requirements of the enterprise for which the survey was undertaken.*

It is true these soundings, as far as they went, indicated no extreme alternations of level along the course traversed. But on the other hand, nothing could be more hazardous than to assume, because a certain degree of uniformity as to depth manifests itself at the isolated spots on which soundings were taken, that a like degree of uniformity must prevail over the wide intervening spaces. Of the spaces themselves we know literally nothing. Nevertheless on these imperfect premises was it maintained, and by many persons believed, that the entire central tract of the Atlantic, instead of being characterized by variations of level and occasional areas of naked and perhaps rugged rock, such as we might expect to encounter here and there in a region so extended, consists of a level plateau, the entire surface of which is covered by a soft stratum of mud, similar to that indicated by the earlier soundings. Now, it must be obvious to every one that, however steep a submerged declivity may be, unless the depth is ascertained at two or more consecutive points, the information elicited will be the same as if the sounding-machine had been dropped on the most perfect level. And accordingly, for aught these soundings have shown to the

* To render this statement intelligible, it may be mentioned that along 1,300 miles of the Mid-Atlantic Telegraph route, only forty-one soundings were taken, the intervals varying between 32 and 71 geographical miles.

contrary, the bed of the Atlantic may present features the most opposite to those that have been ascribed to it. But let us not be misunderstood. It is neither our intention to assert, nor do we believe, that insuperable alternations of level are likely to be encountered. We simply deprecate the hasty adoption of a view so unsubstantiated by proof, and so calculated, if erroneous, to interfere with the accomplishment of one of the most important enterprises of the day.

It should be borne in mind, that the supposed plateau does not comprise a limited area, but one extending for upwards of a thousand miles across the basin of the Atlantic. Now, there is no parallel case to this in any portion of the present dry land. And, since there is no ground for the belief that such a vast area could possibly have remained unaffected by the agencies which produce modifications in the earth's crust elsewhere; it is—to say the least of it—extremely improbable that so signal an exception should occur only along that portion of the sea-bed which has been selected as the site of the Telegraphic Cable. We say *only*, because, judging from soundings taken elsewhere, it is manifest that alternations of level are the rule rather than the exception, and that, in some cases, they are of an important kind.

But it is not necessary to have recourse to soundings, in order to prove the accuracy of this opinion. The islands that rise so abruptly in many portions of the Atlantic, if reduced somewhat in elevation, might occur over and over again within the intervals at which the depths have been recorded, and yet be completely overlooked. Their existence is known simply because they are lofty enough to appear above water. It would be an act of rashness, therefore, to assume that formations similar in their character, but of smaller size, do not occur in positions where they still remain unrecognized.

Of what then, it may be asked, does our knowledge regarding the contour and composition of the sea-bed really consist? The answer to this question is by no means unsatisfactory. Thus, it is certain that in no region of the ocean in which soundings have heretofore been attempted with adequate apparatus, is the depth so inordinate as to be beyond reach. It is equally certain that, as a general rule, the depths are moderate—that is to say, rarely exceeding 2,500 fathoms, or a trifle under three miles; that, for the most part, the bottom is composed of a soft but tenacious mud, consisting either of an admixture of organic and inorganic débris, or of one of these constituents more or less uncombined with the other; and lastly, and pre-eminently perhaps, that deep-seated currents, if they prevail at all, are exceedingly rare and too feeble to produce the slightest deleterious effect upon a submerged Telegraphic Cable. These, we venture to say, are no unsatisfactory results when weighed against the limited and imperfect nature of the opportunities that have hitherto been afforded for the exploration of the sea-bed; and so far from being of a disheartening tendency, they offer conclusive evidence that the perfection of our knowledge with regard to the conditions prevailing along any given tract of the sea-bed, falls readily within our powers, and is merely a question of time and perseverance.

It would occupy too much space were we to enter into the whole of the facts bearing on the muddy deposits, with whose presence, over a considerable area of the sea-bed, the sounding-machine has made us acquainted. But there is one point to which we must invite attention, inasmuch as its importance can hardly be overestimated, and yet, strange to say, it has heretofore been almost entirely overlooked.

In some of the deeper soundings, both on the North and Mid-Atlantic route, fragments of rocks have been brought up. How is the occurrence of these to be accounted for, and what does it betoken? The question is an intricate one, and so far as our present information goes, does not seem to admit of a perfectly satisfactory solution. This much may be said, however; that their presence on the immediate surface layer of the sea-bed, is only reconcilable with one or other of the following suppositions:—They must either have been recently dropped by some means from the superincumbent waters; have been deposited by floating ice during past periods of the earth's history; must occur in beds which were once exposed above the surface of the sea; or be drifting about the bottom through the action of currents.

Now in no case hitherto recorded have these stones been of large size—probably not larger than a hazel nut—but they present undoubted traces of attrition. Fish, as is well known, sometimes swallow small stones, and, as a matter of course, get rid of them in time; but this would not meet the requirements of the first of the above suppositions, inasmuch as it is obviously improbable that so many fish with stones in their stomachs should be moving about the ocean, as would be necessary to account for the fact; and it is still more improbable, if not absolutely impossible, that fish could have conveyed such substances from the distant shores, where they are alone obtainable. So that viewing this circumstance in conjunction with the fact, that no floating ice nowadays traverses the areas referred to, it is quite certain that the matter is inexplicable on the first supposition.

If deposited from floating ice during past periods of the Earth's history (according to the second supposition, which is by no means impossible), it follows as an inevitable consequence that the muddy deposits are local in character, and that certain areas of the sea-bed consist of bare rock; or that they are swept away by currents as fast as they are produced. We regard the first of these two views as most conformable with the evidence; for, although there is reason to believe that deep-seated currents prevail with sufficient force, in some of the shallower tracts of the Atlantic, to move the fine particles of which these deposits are for the most part composed, there is no ground whatever for supposing that they are ever powerful enough to sweep along large objects, such as the stones of which we have been speaking. It will be seen, therefore, that we are fully justified in laying stress on the possibility that extensive areas of exposed rock may occur along the basin of the Atlantic, which have hitherto escaped detection. The third and fourth suppositions are thus disposed of likewise.

But the facts just set forth involve another very important consideration, which, as supporters of no particular creed, we deem it necessary to notice. In assuring ourselves of the absence of currents as a source of danger in Oceanic Telegraphy, we no doubt gain a material point. But to some extent the gain is counterbalanced, and in this wise. Assuming that the bed of the present ocean has been subject, at some antecedent period of the world's history, to the denuding action of atmospheric and terrestrial influences, and has thus been impressed with characters similar to those we see around us on dry land (and that it has been so, there is no valid reason to doubt), whatever asperities may have marked its surface when it was first submerged, must remain stamped upon it up to the present time. The denuding action of water in a state of motion is very great; but that of water in a state of comparative quiescence, such as prevails along the sea-bed, must be extremely limited, if it operates at all. Atmospheric agencies which wear away the rugged features of one district on land and reproduce them on another, are powerless either for good or for evil at the sea-bed. And hence it is certain, that however much the muddy deposits may be constantly contributing towards the toning down of the minor inequalities, they can exercise very little effect as regards those more extensive alternations of level, the absence of which along the sea has been assumed, solely because the means heretofore adopted have been inadequate for their detection.

But let us now turn to the living tenants of these deep abysses. It has already been stated, that although the evidence of the vitality of the minute shell-covered creatures, obtained in the course of the earlier soundings, was altogether inconclusive, more recent observations have established the fact that the conditions prevailing at extreme depths are not incompatible with the maintenance of animal life. The observations in question were made at the close of 1860, during the survey of the North Atlantic route by H.M.S. 'Bulldog.' Into the details of these it would be out of place to enter at present; but the proofs they involve, may be stated in a very few words.

Thirteen living star-fishes, differing in no important particular from a species common on our own and most northern coasts, were brought up from a depth of 1,260 fathoms—or very nearly a mile and a half—at a point midway between the Southern extremity of Greenland and Rockall, and 250 miles distant from the nearest land. These star-fishes, however, cannot be said to have been captured by the sounding-machine, for they came up adhering by their spine-covered arms to the last 50 fathoms of the sounding-line, not as voluntary exiles from below, but owing to their having coiled themselves around a material from which they found it impossible afterwards to disengage themselves. Now, apart from all other evidence, the facts in connection with this particular sounding were sufficient to indicate that the star-fishes had been raised from the sea-bed itself, and had not grasped the line while floating in some stratum of water intermediate between it and the surface. But, by a singular piece of good fortune, the question as to their last resting-place admitted of definite determination on evidence that they bore along with them. To comprehend the value of this, it is necessary to mention that by means of a separate observation taken upon the same spot, the bottom was found to consist almost entirely of the minute shell-covered organisms already referred to; and, taking into consideration the fact that many of the shells were completely filled with the gelatinous substance of which their bodies are composed, and lastly, the fresh appearance of this substance; the probability is very great that they, in common with the star-fishes, had lived and multiplied at the bottom. But the only circumstance which ought to be accepted as direct proof of their vitality, namely, motion after reaching the surface, was wanting; as indeed it well might be, since the passage through the vertical mile and a half of water occupied nearly an hour, and the change of conditions to which the creatures became subjected, during that period, must necessarily have been very great. Nevertheless the chain of circumstantial evidence was rendered complete; for, on examining the stomachs of the star-fishes, they were found to contain the minute shelled creatures in abundance; thus clearly establishing the fact of the star-fishes having attached themselves to the sounding-line whilst it rested on the bottom, and adding the strongest confirmation to the view that the minute creatures referred to were brought up from their natural habitation.

But it was not to be expected that a fact so subversive of all preconceived notions regarding the conditions essential to the presence of animal life on the ocean would be received without the usual amount of salutary scepticism. And hence, on its being boldly announced not only that highly-organized animals had been brought up from so vast a depth, but that they actually arrived at the surface in a living state, scientific men shrugged their shoulders, and demanded the production of the most complete proofs. These proofs we submit have been produced; and they serve to show that instead of organic life being carried on in defiance of the conditions so erroneously held to be incompatible with it, the presence of some of these conditions is indispensable to its continuance. In order, however, to render intelligible the doubts that were expressed on the subject, and the precise bearing of the evidence brought forward with a view to dispel them, it is necessary to draw attention to the conditions on which the determination of the question depends.

According to the generally accepted opinion regarding the Geographical distribution and vertical limits of marine animal life, the presence of one set of conditions is essential, that of another incompatible with it. Thus we are told that a certain amount of aëration of the water, especially with reference to the quantity of oxygen gas contained in a given volume, and the previous existence of vegetable life in some shape or other, are indispensable to the maintenance of animal life; whereas the increase of pressure beyond a certain degree, and the total absence of light, determine the limit in depth beneath which, it was contended, no living being could exist.

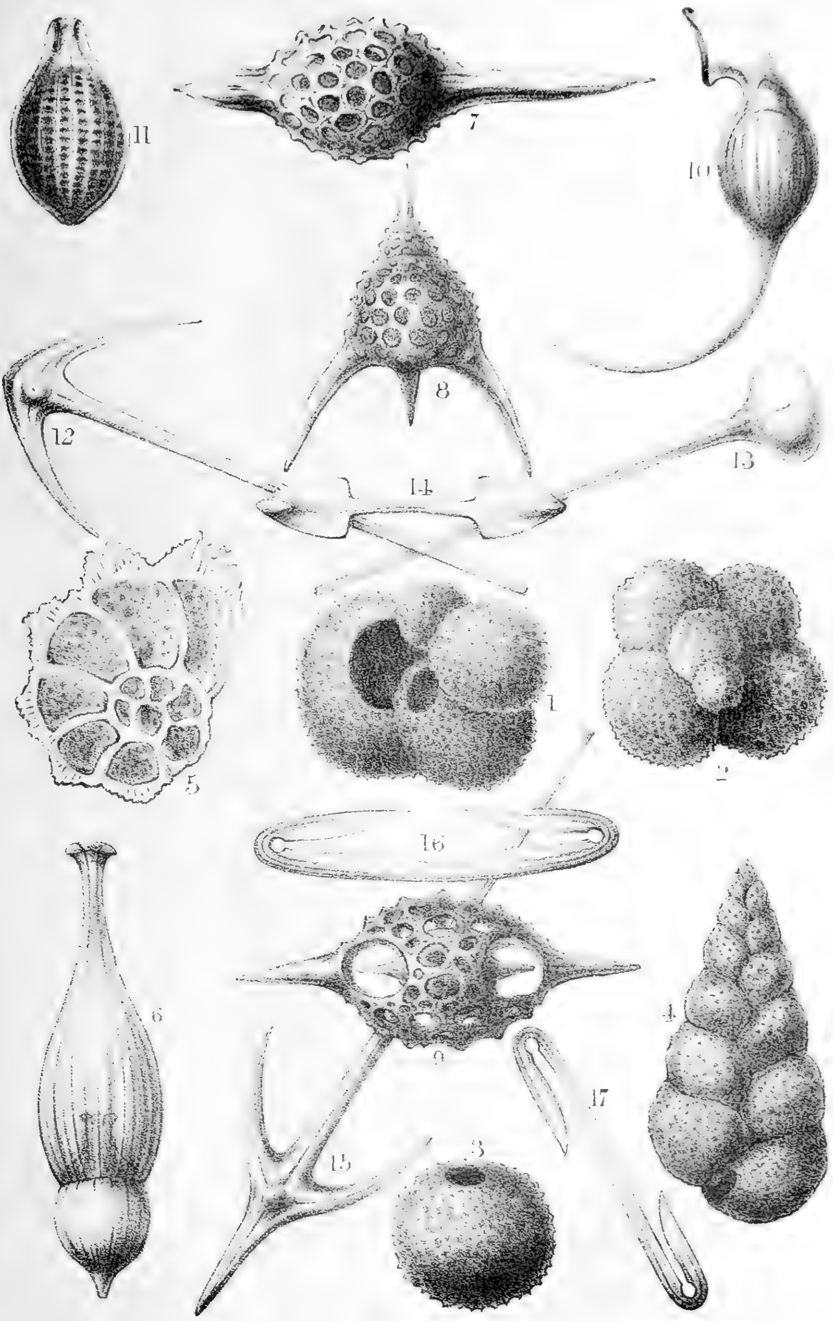
Now, although in the present state of our knowledge, it is difficult to conceive that any animal, no matter how low in the scale, can live in default of a supply of oxygen, we are by no means called upon to believe that this gas is in reality absent in sea-water at great depths.* From observations conducted many years ago by an eminent French experimentalist, M. Biot, it would appear that the swimming bladder of fishes contains a larger quantity of nitrogen than oxygen when they happen to have been captured near the surface; and a larger quantity of oxygen than nitrogen when brought up from a depth of a few hundred fathoms. The researches of other observers would also tend to confirm the view that the quantity of oxygen held in solution by sea-water increases rather than diminishes with the depth; and on theoretical grounds, moreover, there is reason to believe that the presence of oxygen is inseparable from the pressure which prevails at great depths.

In the case of creatures belonging to the higher order, as, for example, fish, the conditions that have been laid down are no doubt indispensable. They cannot support life beyond a comparatively moderate depth; and, as a general rule, it may be taken for granted that no living organism, demanding a supply of free air for its sustenance, or whose structure is of such a kind as to be inordinately affected by an increase of the pressure to which it is subject in shallower water, could, by any possibility, survive a single instant after descending lower than a few hundred fathoms. But there is a large class of creatures, inhabiting the ocean at ordinary depths, whose structure is so universally permeable by fluids that, assuming other conditions to be favourable and the transitions from a low to a high degree of pressure to be sufficiently gradual, it is immaterial whether the medium around them be pressed upon by one or by one hundred atmospheres. In the case of these creatures, as in that of a human being living under ordinary atmospheric pressure, it is only essential that the force should operate uniformly both within and without the body. Hence, in so far as mere pressure is concerned, there is no reason why creatures of the class referred to (and star-fishes are amongst the number) should not be able to exist at all depths.

With regard to the previous manifestation of vegetable life which is said to constitute a condition essential to the existence of animals, both terrestrial and marine, it is only desirable to point out that, were this really a law of nature, it would at once negative the assumption that animal life can be maintained at extreme depths; for, if vegetable products are indispensable for the nutrition of the animal, and no vegetable structures are capable of living in default of a certain amount of light, inasmuch as no light can possibly penetrate to the profounder abysses of the ocean, animal existence must of course be rendered impossible.

But whilst recent explorations of the sea-bed have indubitably indicated that animals can live at those vast depths, they would also seem to show that vegetable life, in any form at least in which we have heretofore detected it, is not co-existent; for whensoever vegetable structures have been found amongst the organic or inorganic matter of

* M. Pasteur, the French chemist, in his recent experiments on Ferments, has sought to show that some of the so-called Infusoria are able to exist without oxygen.



G.C.W. ad nat. del. — Hanhart, Imp. — Edwin M. Williams, Sc

GROUP OF CALCAREOUS & SILICEOUS ORGANISMS FROM THE DEEP SEA BED.

Figs. 1 to 6. FORAMINIFERA. Figs 7 to 9. POLYCYSTINA.

Figs 10 & 11. LAGYNIDÆ. Figs. 12 to 17. SPONGE SPICULES.

the deposits, the peculiar condition of their soft parts has invariably been such as to indicate their having lived in shallower zones, and only descended to the bottom on life becoming extinct. It is manifest, therefore, that the law referred to, however stringently it may apply to terrestrial life, admits of exceptions in the case of marine forms. How these exceptions are provided against remains yet to be ascertained.

But, it may be asked, what are these mysterious little atoms of which so much has been said, and which play so important a part, not only in the composition of the present sea-bed, but of vast tracts of existing dry land. For the benefit of those who have not directed their attention to the subject, we append the following brief particulars and the accompanying Illustrations.

The animal, as already stated, is one of the lowest in the scale of creation. It consists of a minute particle of viscid matter, not unlike the fluid but yet granular portions of honey both as to consistence and colour, and like honey devoid of organization. Nevertheless it possesses vital contractility, and the power of altering its shape to any extent. The little mass is not naked, however, but in virtue of another vital faculty inherent in it, is able to extract calcareous matter from the water in which it lives, and re-secrete it in the form of the exquisite shells known to naturalists under the name of *Foraminifera.* In the deep-sea species to which we are particularly referring, the shells consist generally of a number of chambers ranged in more or less symmetrical order, and each communicating with the rest and with the outer world by one large aperture, and a number of minute pores studded over the entire surface. Through these, the little animal is continually projecting, and as continually retracting, delicate thread-like feelers, composed of the same substance as the rest of the body. By means of these feelers it performs the movements of which it is capable, and, in all probability, is enabled to provide itself with food. Hence it will be understood why it was stated, in a former portion of these observations, that in the absence of these movements it becomes almost impossible to determine whether the object before us is alive or dead.

But although this wonderful little creature demands special notice, owing to the share it takes in the composition of the deep-sea deposits, numberless other forms are to be met with, equally simple in their nature, but still more beautiful in their structure. And this leads us, in the last place, to inquire whether or not there is reason to apprehend danger from their attacks upon a submerged Telegraphic Cable.

On this point we can speak with confidence. If there be any source through which the abrasion of a cable, either by contact with other substances, or the attacks of creatures able to bore into its coverings and thus destroy or impair its insulation, may be obviated, it is through the gradual incrustation that these humble shell-builders are sure to form around it. Accordingly it becomes of the utmost importance to select, as far as is practicable, those areas of the sea-bed which are covered by the foraminiferous deposits, and to avoid those which are bare. Minute Annelids unquestionably exist even at the greatest depths, and amongst these there are some capable of doing mischief. That they can penetrate gutta-percha solely by means of the boring organs with which they are provided, we altogether disbelieve. But, in most cases, there is ground for suspecting that their penetrative powers are materially aided by secretions capable of acting chemically on the substances attacked. Of the nature of the secretion, or its possible effect on caoutchouc or gutta-percha, we know nothing. But this is no reason for repudiating the possibility of an event, which if brought about only once, in the 2,000 miles of cable, would prove fatal to its working integrity. It only remains to be added, that we are no alarmists. We would neither conjure up, magnify, nor ignore danger. What we desire and believe to be indispensable, if telegraphic communication across the Atlantic is to be viewed in any other light than as a source of national chagrin, is that measures should be forthwith adopted to add to the scanty information we already possess regarding the sea-bed; under the firm conviction that whatever difficulties may present themselves, they require only to be understood to ensure their being surmounted.

II. The Atlantic Cable and its Teachings.

By William Crookes, F.R.S.

There is scarcely a question of more importance at the present day, than that of telegraphic communication with India. When these pages are before the public the line which is to connect the two hemispheres will be *en route* to its destination; and judging by the vast experience accumulated during the construction and laying of the old Atlantic line, and the invaluable evidence which on its demise was elicited at the inquest, there is every reasonable hope that the new enterprise will be successful.

A great amount of misconception prevails respecting the now defunct Atlantic cable, and pending the successful termination of the undertaking now in progress, we propose to disinter from the ponderous official documents some portions of its history which are not generally known, and, with the aid of other material now before us, to examine what is the reasonable prospect of success or failure in other similar undertakings.

The problem to be solved is comprised in a very small compass. There is not much difficulty in making a cable perfect as to its electrical conditions, and should any flaw or faulty part happen to pass the first scrutiny, skilled electricians can at once detect it. The great difficulty which now weighs like an incubus upon every large undertaking of this kind, is to submerge the rope without injury. There is now an absolute certainty of making a cable of any length perfect, but we destroy it in attempting to get it to the bottom of the sea. If the insulated wire, in as good a state as when it leaves the contractor's works, could but be transferred uninjured to the ocean's bed, it would lie there as quietly as if it were at the bottom of a well, and would last for hundreds of years.

Unfortunately, the first-laid submarine cables were attended with complete success; these precedents were used as arguments against any further investigation, and hence the hasty enterpriso of the Atlantic cable, involving an expenditure of three-quarters of a million, was rushed into in the most reckless manner, and with so utter a disregard of precautions, as to seem from the first actually to invite failure.

The perfection of a cable depends upon the perfection of each individual inch of it; in this respect it is similar to a chain, which is valueless if a single link be faulty. The insulating covering of the conductor is composed of substances so delicate in texture, and laid on in such a manner as to render it extremely difficult to avoid *faults.* These are generally noticed as soon as they appear, and by taking the precaution to test the cable in definite lengths under water, they can be readily detected at any time, and their position ascertained. What is generally known as a *fault*, is a communication between the conducting wire and the water; this may be either very slight, in which case, the insulation is more or less injured, or it may be sufficient for the whole of the electricity to leak through. A small fault, which would not be of serious consequence in a short line, cannot be tolerated when the cable is of considerable length, as the powerful currents necessary to force a signal through, find out all the weak points, and eat them into fatal holes. There is another reason why faults or even weak places must not be admitted in submarine lines; it is that they are so liable to injury through lightning. In the Channel Islands' telegraph, the lightning struck the cable in Jersey, and passing under the sea along the wire for sixteen miles in the direction of Guernsey, met with a weak place, where it burnt itself through into the water, destroying the insulation.

The material of the outer covering of the cable, and the manner in which it is laid on, are matters of great importance. There must be no strain on the core, and the finished cable must have as little elasticity as possible. Many cables have been injured from a neglect of this precaution: an elastic rope will stretch four or five per cent. during deposition, and will contract when the tension is removed and the temperature is lowered by the surrounding water. The copper wire is however permanently stretched, and where the gutta-percha contracts over it, the wire occasionally knuckles through and produces a serious leakage. The outer coat of mail is almost invariably of a spiral form, which perhaps is the only kind that could be adopted, having regard to the frequent coilings and uncoilings which the rope has to go through, but such a form is very liable to kink whenever the rope is not kept in a state of tension.

The copper of which the conducting wire is now invariably made, should be selected with the greatest care. When pure it is one of the best solid conductors known; but very slight impurities, such as are almost always met with in the commercial metal, are sufficient to greatly diminish its value. Taking the conducting power of pure copper as 100, Dr. Matthiessen found that of samples of American, Australian, Russian, and Spanish copper to be respectively 92, 88, 59, and 14. Since these results have been made known, the wire is always contracted for of a certain specified conducting value per mile.

Much has been said about the deterioration of gutta-percha when exposed to the air, and the great difficulty of avoiding flaws in laying it on the wire; these evils are however greatly magnified. The rotting will not proceed under water, and even in air it may be prevented by a coat of Stockholm tar, whilst the small and unavoidable flaws are perfectly guarded against by applying several successive coatings to the wire. Other complaints brought against gutta-percha, are that it does not insulate very perfectly when warm, and also that it is liable to soften. These are reasons against unnecessary exposure of the cable to heat before its submergence, but are of no consequence when once it is laid. At the bottom of the ocean everything is in favour of its permanence. The surrounding sheath of tar tightly held in iron wires, the low temperature of the water, the preservative properties of the sea, the absence of light and air, and the enormous pressure to which it is subjected, are all elements tending to improve the lasting and insulating properties of gutta-percha.

Many of the most important facts above referred to have been ascertained since the Atlantic Cable was manufactured, but they ought to have *preceded* instead of succeeded so important an undertaking. This could have been done easily by an expenditure, trifling when compared with the amount at stake, and it would have supplied the Company with knowledge which has been purchased at three quarters of a million sterling. There was far too much haste in the preliminary stages of the undertaking. It was looked upon merely as a commercial speculation, and in order to raise the requisite funds, promises to the shareholders were most rashly made. Whilst the Company was only formed in 1856, the line was undertaken to be laid in 1857, and in order to keep faith with the public, the preliminary experiments and investigations, which ought to have occupied the highest available talent for some years, were hurried over in the most reckless manner, or were left to be completed by chance. Indeed, the most important piece of machinery in the whole affair, that for paying out the cable,—an apparatus which would have to run as smoothly as a cotton mill for every minute of the time occupied in that operation, the slightest hitch or irregularity snapping the cable, —was literally being put together for the first time as the ship was sailing to its destination, and was entrusted, untried, with its precious charge. The result may be anticipated. A stoppage in the machinery occurred, and 335 miles of cable were sacrificed at the shrine of official incompetence.

Another great mistake was to have such a rope made of any but the very strongest materials. It was intended at first that the outer covering should be of steel wire, but this could not be adopted owing to the unfortunate promise made by the directors that it should be laid in 1857. Had another year been permitted to elapse, and, instead of iron coating, had steel been employed, there is every probability that the cable would have been at work at the present day. Instead of a breaking strain of three tons it would have borne uninjured a pull of twenty tons, enough, if requisite, to have anchored the 'Agamemnon' in the middle of the Atlantic, and to have endured without damage any imaginable vagaries of the paying-out machinery. The objections that steel cables do not coil as well as iron, and seem "all alive" from their springiness, are not of much weight, as the enormous surplus strength would enable them to bear a considerable amount of hard usage in stowing them away.

In paying out a cable much depends upon its being properly coiled. This was certainly well done in the Atlantic line, and it is doubtless to this fact that the last successful paying is to be attributed. During the whole process of paying out a kink never once occurred; in fact it uncoiled itself, for the men who were stationed in the hold to undo the lashings, and be ready in case of accident, scarcely were required to touch it once.

Few people can imagine the great mechanical difficulties to be overcome in laying a long cable. Owing to the difficulty of making the joinings properly at sea, the rope cannot be carried out in more than two portions, and there are very few ships capable of conveying the required load in the necessary manner. An electric cable is a difficult thing to coil, indeed no one, who inspects it in short lengths, would believe it capable of being coiled at all; the cable must, therefore, be laid in the hold, in as large a circle as possible, and the space occupied must be perfectly clear from cross-beams, or perpendicular supports for the deck. The cable must be placed so as to load the vessel evenly, and must be so paid out that she shall preserve an even keel, otherwise water ballast must be admitted to keep the vessel in trim. Moreover, with a long cable, the vessel employed should be a steamer of sufficient dimensions not only to contain it, but coals as well for the entire voyage, for, if stowed in a sailing vessel and towed by a steamer, the ship becomes in a heavy sea unmanageable, and in case of a hitch occurring, it is almost impossible to check her progress in time to prevent accident. A cable long enough to span the Atlantic will weigh at least 6,000 tons, and when coals must be carried, and in addition a clear space provided sufficient to enable this enormous length of cable to be coiled, it is evident that no existing vessel except the 'Great Eastern,' would be equal to the requirements of the case. The hands employed in liberating the cable coiled in the hold have a difficult task to perform even when the sea is calm and everything goes on smoothly. When at full speed the coils have to be carefully liberated, layer by layer, from the lashings and packings of wood, so as to set free only so much of the cable as is required, so as to avoid the possibility of its escaping from the guides on receiving any check. The break is a part of the apparatus which requires the most delicate handling; the strain which it puts on must be sufficient to prevent the cable from running out with too great a velocity in proportion to the speed of the vessel, whilst it must be sensitive to every pitch and roll, in order to prevent the cable from being snapped by a sudden strain. Many self-acting breaks have been proposed, but in practice nothing has been found so effectual for the regulation of the strain as constant personal superintendence. The speed at which the paying-out vessel travels should be as uniform as possible throughout the whole voyage, and as provision must be made for contrary winds and rough weather, a large amount of surplus power is indispensable. In fair weather it is not difficult to attend to all these precautions, nothing but proper care and attention being necessary; but in stormy weather, when the vessel is tossing to such an extent that the men can scarcely stand while unlashing and freeing the cable, when the pitching of the ship throws sudden and violent strains upon the break, and when the breaksman himself can scarcely keep his feet, and can see nothing in the darkness, the difficulty in managing the apparatus properly is of no ordinary kind.

An indicator is attached to the break, which is supposed to show the strain upon it, but, owing to its inertia, such an instrument is of very little value for obviating sudden jerks. For instance, on the occasion of the first snapping of the Atlantic Cable, the indicator showed a strain of only 35 cwt., although the cable was supposed to be able to resist a strain of 60 cwt.

During the paying out of the Atlantic Cable great doubts were entertained of its permanent success, owing to the serious faults which soon became apparent. The 'Niagara' and 'Agamemnon' having met and joined their respective halves of the cable in the middle of the Atlantic, started thence and proceeded, one to Newfoundland, the other to Valencia Bay, in Ireland, electrical signals being constantly passed from one ship to the other. At one point, when nearly 400 miles had been paid from each ship, the electrical signals became very weak, and the tests applied by the electrician on board the 'Agamemnon,' showed that there was defective insulation at a very remote part of the cable. The fault then seemed to get better, and in about an hour the cable tested as usual. Three days afterwards, when about 560 miles had been paid out from each vessel, considerable irregularities were observed, the signals becoming weaker, until it was reported from the electrical cabin that they had ceased altogether. They shortly afterwards returned, and gradually improved for some hours, when they became as strong as ever. In fact, on the evening of this day (August 2), the signals from the 'Niagara' were reported to be stronger than they had been previously. Other irregularities in transmission were afterwards observed, but the general working of the cable seemed good, and on referring to the memoranda taken by the electricians at the time, we find the signals spoken of as "good" in the morning of the 3rd of August, "first rate" about the middle of the day, and "perfect" in the evening. The next day we have reports of constant signals from one ship to the other, and the memorandum "all right," is repeated several times. On the 5th of August, at 2.10 A.M., the 'Niagara' signalled that she had paid out 1,000 miles of cable, and at 3.50 A.M., the 'Agamemnon' had paid out the same quantity. At that time, intelligible signals were passing through the 2,000 miles of cable, from one end to the other, and in a few hours each ship was safely at anchor.

Thus, then, the possibility of connecting the two continents by an electric cable was proved and considering the unjustifiable haste and disregard of necessary precautions, more than this could not be expected. Indeed, it was scarcely anticipated during the paying out, that any result whatever would be gained. The many coilings and uncoilings which the rope had undergone, had undoubtedly caused injury. The leakage at Keyham was very great, and many bad places were cut out; but as the cable was not once tested under water before its actual submergence, some imperfections necessarily escaped detection.

It soon became evident that very serious faults existed in the cable; its capability of conveying signals varied greatly, going and coming at uncertain intervals, and sometimes stopping altogether; and when to this was superadded the tedious nature of the signalling, owing to induction, it is somewhat surprising that any intelligible messages passed through its whole length. Indeed, had it not been for Professor Thompson, who, without fee or reward, threw himself heart and soul into the affair, the cable most probably would not have spoken at all.

Even when the wire worked well, the sluggishness of the current was a serious obstacle to the reading of the signals. If the 2,000-mile wire had been suspended in air, the signals from one end to the other would have been practically instantaneous; but surrounded as it was with iron and water, great retardation took place from induction, three or more seconds being required for the electric wave to pass along the whole distance. If the discharge at the one end were effected as rapidly and sharply as the charge at the other end, the time occupied in the transmission would be of no consequence, but unfortunately the discharge is always slower than the charge, and consequently a series of sharp crisp dots signalled into the wire at Valencia, would be smeared into a continuous line when they came out at Newfoundland. On this account words could only be transmitted very slowly, the highest speed actually attained being 41 words in 15 minutes. At one time, indeed, two clerks conversed at the rate of 4 words a minute, but most of these words were abbreviated or guessed at before half spelt, so that for ordinary messages, the highest attainable speed may be put down at 2½ words a minute.

On the 10th of August, the first words were sent from America to Ireland, but although the whole day was occupied in such messages as "Repeat, please," "Please send slower for the present," "How do you receive?" "Please say if you can read this," "How are signals?" "Please send something;" and the second day was occupied in similar messages and requests to "Send alphabet," and "Send V slowly," Valencia, like a coy maiden, refused to respond to these entreaties. On the third day, Valencia showed signs of thawing, and condescended to obey the request contained in the following message sent from America:—"If this received, send battery current in one direction five minutes." The next day when America signalled—"Send word Atlantic," Valencia was able to reply, "Atlantic:" (this was the first word read in America.) We then find several words from Valencia in answer to American entreaties, but during the whole of this day, America was signalling to Valencia such messages as these:—"We receive currents, but can't read you," "Can't read." "You must send slower, as some of your dots do not show on most delicate detectors," "We get your currents, but so irregularly, that we cannot read them; will you examine your key well?" On the fifth day, Valencia thawed a little more, and actually asked America to "Send faster;" but although several long messages were sent on that day from America, only isolated words were received in reply. On the seventh day, Valencia and America seem to have arrived at a better understanding with each other, and Valencia asked, "Can you take a message?" with the warning, "You must repeat each sentence in full." Upon receiving an affirmative reply, Valencia telegraphed :— "Directors of Atlantic Telegraph Company, Great Britain, to Directors in America: Europe and America are united by telegraph. 'Glory to God in the highest; on earth peace, good-will towards men.' Repeat back faster. Queen's next." After America had telegraphed back the above message, the Queen's message was sent. This consisted of ninety-nine words, and occupied altogether sixteen hours in its transmission; many parts were repeated over and over again, and the whole message was signalled back to ensure accuracy. After this, owing to the greater delicacy in the reading instruments, and especially to Professor Thompson's beautiful reflecting galvanometer, several long messages were sent backwards and forwards; America, however, always doing the greater part of the talking. On the tenth day, very good signals came, and Valencia asked for the messages to be sent faster. The telegram respecting the collision between the 'Arabia' and 'Europe,' was sent on that day from America, and it was followed by the President's message to the Queen.

Professor Thompson was at this time constantly engaged upon experiments, and the result of these was that the cable spoke much more intelligibly, complimentary messages being sent between the directors and many public men, and several long directions on the details of working the instruments. From this time the cable seemed to improve, and on the twenty-second day the memorable Government messages were sent to America, countermanding the return of the 62nd and 39th Regiments, thereby saving to the British Government the sum of 50,000*l.*

To give our readers some idea of the difficulty experienced in forcing information through the wire, we copy verbatim the conversation which took place in reference to these despatches at the two extremities of the wire. Valencia speaks to Newfoundland at 1.30 p.m. on August 31 :—

"Can you read? We have two Government messages. Will you take? Reply direct."

Newfoundland.—"Try, but send."

Valencia.—"The Military Secretary to Commander-in-Chief, Horse Guards, London, to General Trollope, Halifax, Nova Scotia:—The Sixty-second Regiment is not to return to England."

Newfoundland.—"This received:—'The Military Secretary to Commander-in-Chief, Horse Guards, London.'"

"'Trollope,' understand, go on after 'Scotia.'"

"Is it finished after 'England?'"

Valencia.—"Yes. Now take another. Are you ready?"
Newfoundland.—"Yes, send."
Valencia.—"The Military Secretary to Commander-in-Chief, Horse Guards, to General Officer Commanding, Montreal, Canada:—The Thirty-ninth Regiment is not to return to England."
Newfoundland.—"I want you to repeat 'Canada.'"
Valencia.—"Can't read. Try Daniel's."
Newfoundland.—"Repeat from 'Canada' to 'return.'"
Valencia.—"Canada:—The Thirty-ninth Regiment is not to return."
Newfoundland.—"Understand."

The above occupied eleven hours in transmission.

On the 30th of August, Mr. Field telegraphed from America, as follows:—"Early in the morning of September 1, Please send me message that I can read at the celebration that day, and another on the 2nd that I can read at dinner that evening." Accordingly on the 1st of September, Valencia telegraphed the following message to C. W. Field, New York:—"The Directors are on their way to Valencia, to make arrangements for opening wire to public. They convey through cable to you and your fellow-citizens their hearty congratulations and good wishes, and cordially sympathize in your joyous celebration of the great international work."

Up to this time the condition of the line may be said to have undergone slight improvement. Several long and important communications had been sent through it, and it was on the eve of being formally opened for commercial purposes, when, without any ascertained cause, a collapse took place, and the Atlantic Telegraph suddenly became defunct; its death being the more ignominious when we take into account the message, in the utterance of which it expired. From this date no other sentence could be forced through, and with the exception of isolated words and signals during the month of September, all attempts to restore communication failed. As late indeed as October 20th, eight words of a sentence were spoken through the cable from Newfoundland to Valencia, but this was owing to the employment of recklessly energetic battery power, and may be looked upon as the spasmodic twitchings of a galvanized corpse, rather than healthy vitality.

Let us now try to ascertain the causes of this gigantic failure, and see whether the experience so dearly gained renders a similar undertaking likely to be reasonably successful. It must be confessed that from the first success was almost hopeless. Everything connected with the manufacture of the rope and its subsequent treatment was conducted in such a hurried and reckless manner, that few who knew all the circumstances were surprised at its failure. Before the cable was laid there was great neglect in the electrical department, and the manufacture was carried on throughout without proper supervision. At the whim of any *dilettante* experimentalist, the cable was cut through and through without hesitation, and the joints were frequently cobbled up most disgracefully. It has been estimated that there were upwards of 100 unnecessary cuts, and several imperfect joints have been exhibited, any one of which would be amply sufficient to account for the sudden cessation and reappearance of the signalling; indeed it has been stated on good authority that skilled servants of the Gutta Percha Company who were sent to the contractor's works for the express purpose of uniting the various sections of the cable in as perfect a manner as possible, were dismissed because they made the joints too slowly, and their places were supplied by other workmen. But even then, if skilled electricians had tested the cable properly under water, they ought to have found out the locality of the defects before it was too late to remedy them. When too late it was found that a very serious fault existed about 420 miles from the coast of Ireland. It may be reasonably assumed that this was one of the imperfect joints—good enough to carry the current without betraying itself before the paying out, but—seriously weakened by the repeated coilings and uncoilings that the cable had undergone. This was broken by the strain upon it during the paying out, was temporarily brought together again when lodged on the bed of the ocean, and finally succumbed under the burning discharges from the gigantic induction coils used during some part of the short existence of the line.

Public attention is now being directed to the Persian Gulf cable, which will supply the one link wanting to connect this country with India. If the Atlantic disaster has done nothing else, it has proved the possibility of signalling through vast distances of submarine wire, whilst it has given to practical men such a fund of experience as to render a failure of the Indian line well-nigh impossible. Without going into the details of its construction we may briefly state that the copper wire possesses the highest practicable conducting value; the remote chance of holes or faulty places in the four surrounding layers of gutta-percha has been removed by an intermediate layer of Chatterton's highly insulating compound; the cable has been not only kept under water whilst at the manufacturer's works, but is carried in water-tanks on board ship to its destination, and its electrical condition is tested daily; whilst the outer coating of tarred hemp acts as a protection to the iron armour, and prevents the twisting action occasioned by the rapid passage of the wire spirally through the water during the paying out; for when the cable passes down like a screw through a nut, there is a great liability to kink.

When the cable left this island it was as electrically perfect as we can reasonably hope to get such a line in the present state of our knowledge, and the subsequent operation of paying out has been reduced to such certainty, that there is no doubt whatever about the eventual success of the enterprise. In the submarine lines hitherto laid, all the failures have been due to definite causes which can be readily guarded against. Possibly other causes of failure still remain to be traced out and surmounted, but we cannot imagine any combination of untoward circumstance which could affect the ultimate successful working of the Persian Gulf line. The greatest depth of water in which it will be laid is 60 fathoms, and should an accident happen during the paying out, causing the rope to snap, or should the electricians at either end discover leakage of insulation, or stoppage of the current, there will not be the least difficulty in fishing up and repair-ing the damaged portion. As an instance of the certainty with which the electrical tests now employed can point out the exact locality of a fault, we may mention that in one deep-sea line a defect was detected by the instruments to exist 190 miles out at sea. A ship repaired to the spot, underran the cable, and found the calculation correct within a mile. This being mended, the electricians immediately said that their tests showed another fault about 112 miles farther. This also was found to be the case, with scarcely more error than in the former instance. The bed of the Gulf is admirably adapted for the safe preservation of a cable, being free from those great variations of depth and rocky eminences which effected the ruin of the Red Sea cable. In that instance the line was laid too tensely, and was suspended consequently in festoons between the numerous rocks. It had ample strength to bear its own weight in this position, and at first experienced no harm. Gradually however, barnacles, seaweeds, &c., found it a convenient resting-place; and in course of time they accumulated on the rope to such an extent, as to cause it to break under the additional strain. In the new undertaking, the remote possibility of such an occurrence as this will be avoided by paying out abundance of slack wherever the soundings show much undulation of the sea bottom.

The success which must attend the Persian Gulf cable, and the near approach to certainty of an equally good result in other submarine lines now in progress, ought to remove much of the financial difficulty in inaugurating another attempt to connect England with America. The first line proved the possibility of transmitting messages across the whole width of the Atlantic. This alone was worth all the expenditure incurred; and if the promoters of the new line make use only of the information which the death of the old cable elicited, the public will have no reason to regret the three quarters of a million sterling, now feeding the fishes in the cool depths of the Atlantic.

THE LATE EARTHQUAKE, AND EARTHQUAKES IN GENERAL.

By Robert Mallet, C.E., F.R.S.

Over a large portion of England, people were startled from sleep, shaken by an invisible hand, in the night of the 5–6 October last (1863). A few, at once—and most persons after awhile—realized the the fact that they had experienced an Earthquake, and escaped unharmed. Amongst the tens of thousands thus aroused, who compared notes at breakfast, as to their own reception of the mysterious visitant, how few had, or have at this moment, any notion of the narrow margin during that sudden and evanescent throb, which divided their own fates, between safety and one of the most terrible forms of death—that of being buried, bruised, broken, suffocated, or perhaps burnt alive, beneath the overthrown ruin of their own hearth and home. Slight as was this shock compared with those of other lands, of the terrors of which we delight to read—as of those of war or shipwreck—it well might startle those who felt it, if ignorance were not here bliss to nearly all of us. The pulse that careered over the face of England on that night, like the breeze that sweeps over, and waves a field of standing corn, was probably not greater in the velocity of its wave particle than is the velocity which imparts the shock one may feel by dropping on his heels from a stone-step six inches in height; but had its wave velocity been only as great as that produced by dropping in like manner from the height of a chair, it would have laid in ruins numbers of our English towns, and would have given us a sharp experience, by the loss of life and property, of the mourning and woe that are so often the lot of Earthquake countries.

Indeed, amongst the many natural gifts, referable to Geographical position and Geological structure with which Great Britain has been so lavishly endowed by Providence, none has been more important (though little recognized) in permitting our national development, than our immunity from frequent or severe Earthquakes. We may in this respect, but in a different sense from him of old, "thank God that we are not as other men are." A single shock, no greater in violence than those which occur almost monthly, within less than 2,000 miles of us (in the Mediterranean Seismic Bands)—one, namely, the velocity of whose wave particle should be no more than 12 to 15 feet per second (not so fast as we sometimes move in a carriage), would not only split and prostrate minster, spire, and column, but would leave Manchester, Liverpool, or London, mountainous heaps of brickdust, and rubbish. Terrible as are the consequences of such utter overthrows in the cities of other lands, our artificial conditions would add new horrors to the overturning of our own; for besides the conflagration that almost always succeeds the downfall, ignited by the buried household fires or lights, we should have superadded, the falling in of great sewers, with the overflow of their polluted streams amidst the ruins; the damming, more or less, of great tidal rivers like the Thames, by falling bridges; burst and spouting water mains; gas escaping and exploding in all sorts of cavities amidst these over-ground "goafs," viaducts and iron bridges brought to the ground by their own inertia, tunnels collapsed—coal and salt pits and mines ruined—roof and floor in a moment brought together—complications of horrors such as can be even but inadequately imagined. Happily there is little chance of such a catastrophe. Enough has already been ascertained, as to the distribution in space over the earth's surface of Seismic or Earthquake energy, to admit of our affirming the extreme improbability of the occurrence of any *great* Earthquake in the British Islands; but there is no physical reason why such an event might not occur to-morrow, and it is certain also that the Seismic Bands, *i. e.* the great ribbon-like spaces of maximum Earthquake energy, distributed over the surface of our earth, and which may be seen laid down upon the Seismic mercator of the world, in the British Association Earthquake Catalogue,* are given to wander, and that we have perilously bad neigh-

* 28th Report, 1858.

bours not so far away to the north and south of us, so that a time may arrive, when some remote posterity of our own may become partakers in, if not successors to, their misfortunes. But although our country is thus happily placed in one of the quieter havens of this heaving world (upon the surface of which not a day passes without an Earthquake somewhere, nor any eight consecutive months without one great enough to prostrate buildings over thousands of square miles), and is so circumstanced as never to be very *violently* shaken, yet we *are* shaken much more frequently than people generallyimagine; and now and then, as on the late occasion, the shock is sufficiently severe to be of a very awakening character.

Since the 11th century, there are upon record as occurring in the British Islands, including the Hebrides, nearly 240 Earthquakes.

Statistics have been tabulated which indicate the probability that up to the end of the 17th century not more than one-twelfth of the Earthquakes that occurred in Great Britain were recorded at all, nor more than one-half, up to the end of the 18th century. And at the present moment, there is good ground to conclude that about two Earthquakes per week shake the soil of England, Scotland, or Ireland, without counting minute and continually repeated vibratory jars, such as those long remarked at Comrie in Scotland. Now and then, some of these British shocks are not quite to be despised; for example, on the 13th of August, 1816, an Earthquake, that extended with violence over more than 100 square miles of Scotland, shook down part, and twisted upon its base the whole of the spire of the church of Aberdeen. On March 17th, 1843, an Earthquake, great enough to damage buildings, occurred in the North of England, and reached from Northumberland down to Flintshire, and from the Isle of Man to beyond Cheshire; and no longer ago than on the 9th November, 1852, a shock which threw down strong walls at Shrewsbury, extended over the British Islands from Dumbarton nearly to Dartmoor, in Devon—and from Enniskillen, in Ireland, to Gainsboro' in Lincolnshire.

Nothing was so remarkable in the mass of letters from Correspondents as to the late Earthquake (of October) with which 'The Times' and other Papers were for a few days afterwards filled, as the dense ignorance that prevails amongst all classes as to the nature of these phenomena, and of the circumstances that it is desirable to observe with respect to them.

One writer's letter contains literally but two facts, that "he felt something" which he thought must have been an Earthquake—and that "he got up, and immediately lighted a candle,"—he might have added, that in this case he did not put it under a bushel! The pseudo-scientific "communications" chiefly record the exact state of Barometer and Thermometer at the moment of shock; facts now known to be nearly as irrelevant as the price of Consols the day before. Nor is this ignorance confined to the more "ignoble vulgar," for a professed Meteorologist, for the benefit of the public at large, prints in 'The Times' a string of inquiries to which he demands answers, but which point to nothing so clearly as the writer's ignorance of the subject that he meddled with, and which he seems to think is still, as in the venerable days of Aristotle, a branch of Meteorology; at the same time we happen to know that that Journal declined to give publicity to a carefully drawn up series of inquiries prepared for it by a competent person.

The fact is that Seismology—which has only become a science since 1846, and has since advanced with very rapid strides—has as yet not become diffused at all widely, even amongst the proper brotherhood of Science, and no attempt has been made to popularize it for the less informed reader. It occupies just now about the same relative position that Ice Theories did in 1837, when at the Liverpool Meeting of the British Association, the very first Paper that appeared in English on the Motion of Glaciers was read (on sufferance) in the Geological section; the President observing that, "as the topmost and most recent of all deposits, Ice might certainly be conceived as having *something* to do with Geology;" but no one then saw any importance, or great Cosmical relations, in the subject that since has engaged so many minds, and been shown to play so important a part in the terrestrial machine, and which, having passed into popular hands, is now being "run away with" by some Geologists, who attribute to its past or present agency many gigantic tasks that, tested by only a little exact science, would prove to be impossible. No doubt something of a like fate is in store for Seismology. Those—the few—who will master the preliminary science absolutely necessary to understand and make use of it, will find in it the key to some of the greatest, and hitherto amongst the most obscure, problems of Physical Geology. Those who will be content with scraps of knowledge, or with being told results, like children, will be amused; and, in proportion as they know more, will they be better amused, with Earthquake stories. But though they will then to some extent comprehend, they can never make for themselves real advances into the unknown. On the contrary (as with many Glacialists in relation to Geology), they may oftener, if they make the attempt, "darken counsel by words without knowledge;" for the half knowledge of ingenious men is always "the Philosophy of the unconditioned." But although this is peculiarly the popular career of such parts of science as seize upon the imagination by the grandeur of the phenomena they discuss, and admit of a smattering of their reasonings being attained without great mental effort,—still it is well, here as everywhere, that those who actually scaled the rugged precipice of science, when they have reached a firm foothold upon a new or higher ledge, should turn round and announce to those that labour in the plain, the wider and nobler horizon of nature they have commanded.

It is good, therefore, that Science (worthily so called) should, as far as possible, utter her voice intelligibly to all. Let us humbly try to do this in part for the new-born Science of Seismology; but we must begin at the beginning, albeit we may not in this paper reach the end. And first, let us understand what we are speaking about. What is an Earthquake? Our readers are confident that they can answer *that* inquiry. There are some who have read, many who have talked of them, and some even who have felt their effects. But what *are* these effects? and the cause—what is it? Let us mention one or two things which an Earthquake is *not*. It is never "one of the means by which permanent geologic elevations of the land are produced," though too often confounded with these in all sorts of geological "systems," and *ex cathedrâ* utterances. Nor is it "the reaction of the interior of a planet upon its exterior," for that, oracular as it sounded from the lips of a Humboldt, is, in fact, to say nothing.

What, then, *is* an Earthquake? *It is the transit of a wave or waves of elastic compression in any direction, from vertically upwards to horizontally in any azimuth, through the substance and surface of the Earth, from any centre of impulse, or from more than one; and which may be attended with sound and tidal waves, dependent upon the impulse, and upon circumstances of position as to sea and land.*

To understand the definition we must have a clear notion of what a wave is. We will return to that true threshold of Seismology, but first let us take a very brief glance at the history of our subject. This is twofold: that of the facts, or reputed facts, as found in innumerable Earthquake narratives, and that of human opinion, from the dawn of knowledge downwards, as to these, in referring them to causes.

The supposed first cradle of our race, or at least of that great branch of it from which we ourselves, and almost all our knowledge, have come, was situated in regions that during all history, as now, have been greatly disturbed by Earthquakes, which thus very early engaged the minds of the more observant of men. Nothing, not even thunder and lightning, amongst natural phenomena can have so impressed the imagination of early peoples, as did these suddenly felt shakings, by a terrible and unknown power inhabiting the unseen depths of the Earth, nor more imperatively stimulated to the discovery of some cause for them.

The genius of the old nations of the East, that always "sought after a sign," or for a final cause, was and is satisfied with a myth. When Brahma turned sides, there was an Earthquake, or when the Tortoise, on which the world rests, stirred his flippers, there was the like result; and this sort travelled westwards, moulding the earlier than Homeric Mythology of the days when Greece was young, and showing itself in the mysterious power of the Trident of Neptune, Σεισιχθονος ἐννοσίγαιος. But the Greeks "desired wisdom," and only missed it as to deciphering nature, because they started from archetype creations of the mind, and not from inductive observation.

There was plenty of such philosophizing on Earthquakes amongst them. There were three theories before the days of Aristotle: that of Anaximenes, the Milesian; of Anaxagoras of Klasomene; and of Democritus of Abdera, in order of time. Aristotle himself wrote largely and learnedly in the books περι Μετεωρολογικων, and περι Κόσμου. He had remarked and classified, with his accustomed comprehensiveness, the different sorts of shocks by their sensible effects, dividing all into, ἐπικλίνται, which strike the earth's surface at an acute angle; βρά-σται, those that come right up (vertically), and sink down again, like a boiling spring or pot; χασματίαι, those that leave hollows after their departure; ῥῆκται, those which break forth with eruption of wind, stones, mud, &c. Those which with one great push overturn everything are ωσταις, and those, that with much shaking to and fro, and up and down, replace the objects they have displaced, and are of the nature of tremors, are παλματίαι.

The first, the second, and the two last, are clear, and almost exactly expressive of the sensible differences of Earthquake shocks: but in the two between, Aristotle either classes Volcanic Eruptions with Earthquakes as all parts of one common train of events—or confounds the shock with its consequences, *i. e.* the Earthquake with its secondary effects. Beyond the proof which this classification affords, that nearly two thousand five hundred years ago, Earthquakes were much the same as they are now, no man can learn anything from the disquisitions of Aristotle.

Partly from the Greek being in these passages in many places corrupt, but far more from the fact that the Greeks had no distinct notions as to those forces of matter we call "molecular," nor yet any clear metaphysics, an abuse of words is found in their Physical writings which often renders them almost unintelligible: πνεῦμα is in some sort the cause of all earthquakes, says Aristotle; but whether by the word, he meant simply the winds, or some intangible imponderable force or agent present in the earth and above it, acting upon the winds, and acted on by them, though not the winds themselves, and giving rise to Earthquakes and Volcanoes, it is impossible to determine. The word πνεῦμα was used to express pure spirit, and the wind, as well as condensable vapours, indifferently and alike, by the vulgar, and by the philosopher. Thus in John's Gospel, cap. iii. v. 8, this word occurs twice in the same verse, and is translated wind first, and spirit afterwards in our version.

The views of the great and philosophic Seneca are far more distinct and important. What Humboldt wrote, was true at the time, and the 'Questiones Naturales' contain the germ of almost everything that has been advanced in modern times as to Volcanic action in its larger sense.

But we must hurry away from classic days, leaving Pliny without notice, and pass on and over the centuries of the so-called dark ages, and of the revival of knowledge, remarking only that in the fifteenth, sixteenth, and seventeenth centuries, innumerable pamphlets and books were published, most of them recording with a grand *gobemouche* credulity, all sorts of signs and wonders, and straightway founding a theory thereon. In the seventeenth century, these usually "improved the occasion" by pointing out that the particular Earthquake was a special judgment on some unfriendly nation or obnoxious creed. The crudest and wildest hypotheses were set forth, and more or less accepted to account for the production of the shock. Thus it was due to *solutio continui* in the parts of the earth, to a sudden penning in of the subterraneous fires, to sulphureous and bituminous blasts, or, as Dr. Stukely was of opinion, to the play of lightning and thunder underground in manner like to that wherein they appear in our firmament. In nearly all these, Earthquakes and Eruptions are impartially jumbled. It is only within a very short time, that a few men in Europe have come to see, that while VULCANICITY is a word that may properly express the community as to causation that exists between

Earthquakes and Volcanoes, yet that these must be treated and investigated up to a certain point as distinct, and that SEISMOLOGY shall express the system of doctrines of the former, and VULCANOLOGY that of the latter.

There are a few bright points of observant thought to be found amidst all this "old world" muddle, however.

Fromondi, who wrote, in 1525, six books on Meteorology, and devotes the fourth to Earthquakes, refers to the explosion of the great Fire Ship, by which the beleagured Antwerpers blew up the Duke of Parma's bridge over the Scheldt, of which Mottley has given so spirit-stirring an account in his 'History of the Revolt of the Netherlands.' Fromondi remarks, that the blow of its explosion was felt almost all over Holland; and he seizes upon the analogy between the effects and those of Earthquakes; but he soon loses the train of thought that had thus so well broken cover.

Maggio, of Bologna, in 1571, was the first who made any attempt to collect and classify into eleven, the signs or presages of Earthquakes, not with much light, it must be confessed, as he put Eclipses and Comets amongst "the eleven."

Then, just about a century later, came Travagini, to whom belongs the credit of the first attempt to found a Physical Theory of Earthquake movements, and whose disquisitions present a notable example of how a man may go coasting along very near to a great truth, and yet never touch it.

He had experienced a horrible Earthquake in 1667 at Ragusa—seismically a very ugly region, being that where the great seismic band which stretching away westward from Varna and Constantinople along the Balkan, crosses the Adriatic,* and joins on to the great Italian band at Gargano and Melfi, and a place still subject to frequent and violent disturbance.

That the shock was due to some kind of impulse or blow, and that the force was in some sort dispersive, is all of truth that can be said to have been seen clearly by Travagini, though he was close to a great deal more.

Hooke, in 1690, delivered his 'Discourses of Earthquakes,' before the Royal Society. These Lectures, though called so, are, in fact, a diffuse sort of system of Physical Geology, and full of suggestive thoughts; but Hooke throughout loses sight of what an Earthquake really is, and confounds all descriptions and sources and degrees of elevatory forces and their effects, with the transient action and secondary effects of Earthquakes properly defined. These Lectures have been the mine from which numberless later Geological authors have more or less consciously drawn, and while they are a repertory of curious and often valuable thought and information, they have done great mischief in being one of the main causes of the same confusion of ideas between the effects of Land Elevation, and those of Earthquake, which is not even yet cleared out of Geological systematic authors.

In 1760, the Rev. John Mitchell, Fellow of Queen's, Cambridge,

* See Map D, 'Report to Royal Society on Neapolitan Earthquakes of 1857.'

produced a most remarkable paper on Earthquakes to the Royal Society, printed in the 'Philosophical Transactions,' vol. li.—attention being then powerfully directed to the subject by the recent terrible shock that had destroyed Lisbon.

He shows a wonderfully clear conception, for his time, of the general configuration and structure of the superficial parts (or crust as it is the fashion to call it) of the Earth, and of the relations between Volcanoes and Earthquakes. Both, he supposes, are due to vapour of high tension almost instantly generated by contact of water with incandescent rock, deep in the earth. Misled, however, by his conception of the universality of horizontally disposed strata, and of a nucleus of liquid lava universally beneath them, he goes at last hopelessly wrong, by supposing that Earthquake-shock consists in a liquid wave of translation produced in the lava sea beneath, which forces, as it travels, the flexible covering of stratified material overhead to undulate along with it, just as "a large carpet spread upon a floor, if it be raised at one edge, and suddenly brought down again—the air under it by this means propelled, will pass along until it escapes at the opposite side, raising the cloth in a wave all the way it goes." This paper though vitiated throughout by this leading fallacy as to the nature of the Earthquake wave, was a most meritorious performance, and had important effects (though little specifically noticed), in moulding the thoughts of the earlier schools of Geology.

Bertrand, Bouguer, Ulloa, Dolomieu, Grimaldi, Hamilton, and the Neapolitan Royal Commissioners, accumulated a mass of facts (and, let us add, of fictions) of Earthquakes, in the last and beginning of this century.

Humboldt added to the facts in his Personal Narrative, &c.; but nowhere, not even in 'Cosmos,' does he show that he had any clear notion of what is the nature of Earthquake motion—or how produced. In 1835, the Comte Bylandt de Palstercamp, in an extremely curious though wild and imaginative work, "La Théorie des Volcans," attempts to build up a sort of Cosmogony from considerations of the relations and reactions on our planet, of light, heat, electricity, &c., &c.—from these come Volcanoes, and from the latter Earthquakes. Truth and quasi-truth are wildly and incoherently mixed in his book. Shocks or blows produced by and transmitted *through cavities*, lifted up and down by sudden filling or emptying of aëriform fluids, form Bylandt's shock,—and starting from the following extraordinary propositions, "les effets des tremblements de terre sont toujours contradictoires aux causes qui les produisent et dirigés dans le sens inverse,"—"l'effet sera celui d'un pendule, c'est-à-dire contradictore entre les deux extrémités," he arrives at the *true* conclusion, that bodies overthrown at opposite sides of a seismic focus will all fall *towards* it, but in *opposite* directions to the shock and to each other. We now know that this is only true if the bodies fall in the first semiphase of the wave. Had Bylandt followed this out, and curbed his tendency to mysticism, he would in all probability have been the creator of Seismology,—the true discoverer of Earthquake dynamics—as it was, he missed the prize.

Between 1820 and 1841, Von Hoff, Kries, Hoffmann, and one or two others, had laboriously collected and digested into order a large mass of facts, or reputed facts, of earthquakes, and to the first belongs the credit of having, in a masterly discussion,* shown what are the relations (so far as then known) between Meteorological and Earthquake Phenomena—and pointed out, that all the supposed meteorological presages were devoid of reality, and that Earthquakes belong to Physics and Geology and not to Meteorology.

But none of these men made the slightest advance towards a physical theory of Earthquake *motions.* The only true *hint* even, that was to be found before 1846, as to the true nature of the Earthquake motion, is found in a paper on Volcanoes, by Gay Lussac, in the 'Ann. de Chim.,' vol. xxii. p. 429, who quotes from Dr. Young's Lectures, and concurs in his opinion, that "Earthquakes were of the nature of vibrations in solids." Even Darwin—who of all men had had the finest opportunity of seeing the effects of Earthquake on the most extensive scale in South America—rendered no better account of the then accepted Vorticose displacement of objects, than by asking, "Might it not be caused by a tendency in each stone to arrange itself in some particular position with respect to the lines of vibration, in a manner somewhat similar to pins on a sheet of paper when shaken?"

He, too, like Parish, had recorded the circumstances of the great sea-waves that roll in, after South American and other Earthquakes, but neither rendered any solution of the facts. Nor was an attempt made by anyone, as yet, to connect these sea-waves and the sounds heard in great Earthquakes with the other parts of the phemomena.

A considerable advance had been made in a branch of science apparently remote enough from Earthquakes, which, however, greatly prepared the way for solving one part of their true history. The brothers Weber, in Germany, and Scott Russell after them, in England, had experimentally developed the science of certain classes of liquid waves; and the latter had, in 1844, shown the laws of propagation of one class of these, *viz.* waves of translation.

In February, 1846, a paper was read to the Royal Irish Academy, and then published in its Transactions, vol. xxi. part 1, "On the Dynamics of Earthquakes," which (we quote the words of the President, Dr. Chas. Graves, on presenting the Cunningham medal) fixed upon an immutable basis the real nature of Earthquake phenomena, and, for the first time, showed that the three great classes of phenomena —1, Shocks; 2, Sounds; 3, Great Sea Waves—were all reducible to a common origin, and formed parts of a connected train, and were explicable upon admitted laws. This paper also, for the first time, explained the true nature of the movements that had been called "vorticose," and viewed as proofs of circular movements, by showing that they were the result of rectilinear motions.

It also pointed out the important uses that might be made of Earthquakes, as instruments of cosmical research, enabling us not only to discover the depth beneath the surface of the origin of these shocks, and hence of volcanic foci, but ultimately of ascertaining the nature,

* Geschichte der natürlichen Veränderungen der Erdoberfläche.

as well as the temperature, of the formations within our earth, to a depth far more profound than can be reached by any other mode of investigation, or directly ever reached at all, and that by its means, we may acquire some knowledge of the formations constituting the beds, or situated even far beneath the beds, of the great oceans. These are, in fact, the great aims of Seismology, for the investigation of Earthquakes is only a means to an end.

This paper drew the attention of physicists and geologists, in a prominent manner, to the subject of Earthquakes, and was followed by several reports drawn up by desire of the British Association, and published in its volumes; and also by the laborious task completed in 1858, of drawing up and discussing the 'British Association Earthquake Catalogue.' For this large body of seismic statistics, embracing all historic time and the whole earth's surface, and numbering more than 6,000 Earthquakes, the groundwork had been laid by the immense and valued labours in the same direction of Von Hoff, and of M. Perrey of the Faculty of Sciences of Dijon, whose life has been devoted to this branch of the subject, and whose labours are still continued with the enthusiasm and success of his early youth.

Since 1846, the experimental method has been brought to bear upon the subject; and the observations made on natural shocks have been compared with those of Earthquakes artificially produced. And now Seismology has taken an acknowledged place as an important and productive branch of Cosmical Physics, and already some able men in different quarters of Europe are pursuing its study. Amongst those who have most, and most recently, advanced our knowledge, are Haughton, Favre, Schmidt Jeittelles, Otto Wolger, and Kluge. But we have now brought the history of discovery in Seismology to such a point, that its further development will best merge into the remarks to follow, upon the doctrines and facts of the Science itself.

Recurring now to the definition already given of an Earthquake, we will clear our ideas as to what it means. The shock is produced by a *wave of elastic compression* passing through some portion of the substance of our earth. Elasticity is that property in matter which tends to the restoration of *figure* in solids, and of *volume* in liquids and gases, when altered by an extraneous force; and every different substance has its own co-efficient (or measure) of elasticity of volume (cubic elasticity), and of elasticity of form (linear elasticity).

In common parlance, it is often confounded with flexibility. Thus, when people praise the springs of an easy-going carriage by saying, "they are so elastic," they mean they are so flexible. Elasticity and flexibility are, in fact, opposites in some respects. A perfectly elastic solid is one that, after forcible alteration of figure completely restores itself; if perfectly flexible, it would not restore itself at all, and might be bent to any extent without disruption. No such bodies exist in nature. All terrestrial materials present variable combinations of elasticity and flexibility, neither being perfect. Thus, Glass, Ivory, Agate, and Hard Steel are highly elastic bodies, but very slightly flexible. They break, as we all know, if but slightly bent, or when struck sharply a blow which bends them suddenly, but they almost perfectly resume their forms after being released from an inflecting force.

On the other hand, India-rubber, Animal Jelly, and Whalebone, possess a wide range, both of flexibility and of elasticity. They recover their forms after great distortion, but not so perfectly as more rigid bodies. The *elastic limit*—that is, the extent to which their particles may be relatively displaced without fracture or other permanent alteration, is much greater in these latter, than in the former class of bodies.

But we find also bodies which, like dough, or tempercred potter's clay, are extremely flexible, and exhibit hardly any tendency to resume their forms when these have been forcibly altered.

All these are solids, *i. e.* more or less rigid bodies, but liquids and gases are also elastic; liquids do but very slightly—gases not at all—resist change of figure, but they powerfully resist change of volume; and when this is altered by compression, it is restored by elasticity. Thus a cannon-shot that strikes the surface of the sea rises and ricochets in virtue of its own elasticity and that of the water, from which it rebounds much farther than from a bed of solid clay or of sand; but the range of the elasticity in volume, of liquids, is extremely small—so little, that if the weight of our atmosphere pressing upon the ocean were doubled, it would only squeeze about every million and forty-five cubic yards of water into a million. Gases, on the contrary, as we all know, are largely compressible, and perfectly restore themselves to their original volume; of this the air-gun affords an instance familiar to everyone.

Solid bodies may be deformed *by flexure*, as when a carriage-spring is bent; by *extension*, as when we pull a cord or wire endwise; or by *compression*, as when a load is laid on the summit of a column; or any combination of these may occur by the application of partial forces to their forms. But further, solids may be either homogeneous or heterogeneous, made up of different particles, or of particles having different elasticities in different directions. Thus, certain crystals have different elastic co-efficients in three different axes; and pseudo-crystalline bodies, such as the laminated slate of North Wales, or closely stratified rocks, have very different degrees of elasticity parallel to and transverse to the lamina, or to the strata, respectively.

It is in virtue of this restorative force of elasticity, that whenever a blow or pressure of any sort is *suddenly* applied, or a previously applied, steady or slowly variable force, is *suddenly* increased upon or relaxed from, any material substance, then a *pulse* or *wave* of force, originated by such an *impulse*, is transmitted through the material acted on, in all directions from *the origin* or *centre of impulse*, or in such directions as the limits of the material permit. The transfer through the material, or the *transit* of such an elastic wave, is merely the continuous forward movement of the original change in the relative positions of the particles of part of the elastic mass produced by the extraneous force or blow—a relative displacement and replacement of those particles within a determinate volume of the material, transferred through and affecting in succession, the whole mass.

The shaking of the ground by the rolling of carriages, beating their wheels upon the paving-stones in the streets of cities, and the still more perceptible rocking of the ground beneath our feet as we stand near a heavy railway train at speed, are examples of such waves in solids.

The ordinary sounds we hear, are examples of like waves in air; and the noise of the grating and rolling pebbles moved by the waves as they approach the shore on which we stand, is an instance of such waves, transmitted from the mutually struck pebbles to the water, and through the water to the air, by which it reaches our hearing organs. While the shock or jar felt in a boat floating at some distance from a blast exploded at the bottom of the sea, is a case of such an elastic wave, originated by the blow of the powder, and transmitted directly to and through the water and the boat, to our bodies.

Now the velocity with which such a wave-form travels, varies in different materials, and if these be homogeneous, depends for any given substance, principally upon its specific degree of elasticity—technically called its *elastic modulus*, and upon its *density*, upon which its mass and inertia are dependent in a given volume. The rate at which the *wave-form, i.e.* the whole group of displacing and replacing particles in simultaneous movement, is transmitted in any particular substance, is called its *transit period.*

This period is *constant* (always the same) for the same material, under the same conditions as to temperature, molecular state, &c., and for small originating impulses is irrespective of the amount or kind of the original impulse which produced the wave. Experiments conducted within a few years past at Holyhead, as to the time that the wave or shock, transmitted through the Quartz and Slate Rocks there, to traverse a measured mile of rock, from the moment of production by certain of the explosions of the great mines, employed in the adjacent Government Quarries, which vary from less than a ton up to six or seven tons of powder fired at once, appear to indicate that in elastic waves of this great magnitude and transmitted through heterogeneous material, *i. e.* laminated, contorted, and shattered rocks of various degrees of hardness, density, and elasticity; the transit period is not independent of the amount of the original impulse, but that the larger this is—and the greater consequently the original magnitude of the wave—the less (in some ratio) is the time of the transit period; in other words, the faster the wave travels.

In air, the transfer of this elastic wave, which is identical with that of *sound*, has a velocity of about 1,140 feet per second. In water, the transit period is about 4,700 feet per second; and in hard crystallized rocks, such as porphyry or granite, if they were perfectly solid and homogeneous, it would be from 5,000 to 10,000, while in iron and steel it reaches 11,000 or 12,000 feet per second. An enormous retardation of this transit velocity occurs however when the material through which the wave passes is heterogeneous, broken up and shattered. When first it was pointed out that an Earthquake shock was an elastic wave, it appeared, upon physical grounds, that the rate at which the shock having reached one place on the earth's surface, would pass on to another beyond, must be something nearly as great as that theoretically due to the elasticity and density of the rocks beneath, that is to say, often as much as 8,000 or 10,000 feet per second. This was submitted to experiment; granite rock, highly elastic and dense, ought to transmit a shock wave nearly as fast as any rocky or other material forming part of our globe, and wet sand ought to transmit it almost at the extreme limit of slowness.

More than a mile of wet uniform sand was measured carefully upon the shore of Killiney Bay, in Ireland, and several hundred feet in the granite of Dalkey Island adjacent. At one end of each of these ranges, respectively, small Earthquakes were made by exploding galvanically, casks of gunpowder buried in the sand, and blasts sunk in large cylindrical holes sprung in the granite, special means being devised for determining the time of transit, and accurate enough to measure time to less than the five-thousandth of a second; the time-measuring apparatus being set in motion, and stopped by the same galvanic apparatus that fired the powder a mile or more away. An instrument, called a Seismoscope, was also devised and employed, by which the arrival of the wave of impulse transmitted from the powder exploded at the remote end, should be rendered visible to the eye, through the disturbance of a telescopic image, reflected in the liquid mirror of a small trough full of quicksilver, which was caused to undulate and flicker by the momentary tremor of the ground beneath it. The sensibility of this instrument was so great that a horse trotting on the sand half-a-mile away was visibly seen to shake the ground, and a stamp of the foot or tap of a hammer on a large stone several hundred feet away, produced visible disturbance. This instrument was also employed at Holyhead.

The results of these experiments caused some surprise amongst physical philosophers, for in place of the enormous rates of transit that were expected, it was ascertained that the mean rates of wave propagation were only as follows in the respective media, *viz.*:

In the most solid Granite	1664·574	feet per	second.
In shattered-like Granite	1306·425	„	„
In contorted and stratified Rock (Quartz and Slate)	1088·559	„	„
In wet sand	824·915	„	„

The retardation is due to the discontinuity of the rocks, the mass of every known rock being broken up by joints and fissures, at each of which there is a loss of *vis viva*, and a loss of *time* in the transmission of the wave. The accuracy of these results, at first received with some just reserve, has since been amply confirmed by observations and calculations of the actual transit periods of Natural Earthquake waves, occurring in the Rhine Provinces, Hungary, and Southern Italy, which are found closely to co-ordinate with those of experiment.

It was ascertained that in the contorted heterogeneous and shattered rocks of Holyhead, no less than *seven-eighths* of the total theoretic velocity of transit due to the elasticity of the rocks, which was also experimentally obtained, was extinguished thus by their want of continuity, &c.

Now, from these different rates of wave transit in diverse materials, it results that if an impulse be given at a single point, it may be perceptible several times in succession by a person so situated as to receive it through different media.

Let, for example, one stand near a line of railway, and a heavy blow be delivered upon the iron rail; it will be *heard* first, through the iron rail; almost directly afterwards a second sound will be heard through the air; and almost at the same time the person will *feel* the pulse of the blow reach his feet through the ground. While, if another person had his head immersed in the water filling a side drain along the line, he would have heard the sound through the liquid at a moment different from the arrival of any of the other waves.

Such waves, only on a larger scale, constitute an Earthquake shock.

An originating *impulse* (something of the *nature of a blow*, or *having the effects of one*) there must be for every shock, but we are not here concerned with the source from which that impulse may be produced. It may be an explosive production or condensation of high-pressure steam in heated cavities, deep beneath the surface, or *sudden* increase or decrease of its tension, or sudden fracture or fall, or forcing up or down or against each other of great rocky masses, or if (in near propinquity to active volcanoes), it may be any of their throbs or throes, or explosive ejections, or the recoil from these; it matters not as respects the physical theory of Earthquake-motion, and the explanation this renders of Earthquake-phenomena, what or which or whether any of these be the cause of the blow, so long as some sort of impulse be given, and the seat of this be more or less deep beneath the earth.

Then in all directions outwards from this centre of impulse, there will be transmitted an elastic wave. The form of the wave, if originated at one point, would be that of a spherical shell concentric with the centre of impulse, if the medium were quite homogeneous; but in nature, the wave assumes ellipsoidal and various other more complex forms, and rapidly gets broken up into smaller and still more complex waves, by dispersion, by interference, refraction and reflection, in consequence of the shattered and varying nature of all the superficial formations through which it is transmitted.

The wave starts from the origin with one normal and two transversal vibrations, *i. e.* every particle vibrates not only to and fro, in the radial direction from the centre, but also at right angles to this, in two directions at once. The former is the larger vibration and the more important to attend to, so that we may often, in investigating Earthquake-phenomena, altogether pass over the transversals. These vibrations constitute the proper motion of the wave as contradistinguished from its motion in transit.

A plumb line passing from above the surface of the earth and through the centre of impulse is called *The Seismic Vertical.* The wave or shock passing outwards from this centre, reaches the earth's surface vertically, and soonest in this Vertical, which is the shortest distance between any point below and the surface, and here it only produces (neglecting transversals) a rapid movement up and down. The surface of the ground actually rises and sinks again to its previous place, with great rapidity, and through a range that may be several inches or perhaps feet, dependent on how great and how near the blow is given below, and what is the intervening material.

For all points around the Seismic Vertical, the wave emerges at slopes, called *emergent angles*, which become more and more nearly horizontal as the distance on the surface is greater. The spherical or quasi-spherical shell wave-form at any given distance outwards when cut by the earth's surface, intersects it as a closed curve, more or less circular, elliptic, or oval, and the crest, so to say, of this surface-wave, called a *coseismal line*, because all bodies situated in it are shaken at the same instant, travels along the surface of the earth with a real, though not large, and with a constantly diminishing *undulation*, like a roller at sea, constantly enlarging the curvilinear area within it; and as it passes outward, objects in succession are disturbed or overthrown, *not by the transit of the wave-form, but by the wave itself*, that is, by the movement of the particles in motion in the wave.

There is a certain distance outward upon the earth's surface, all round the *Seismic Vertical*, at which it may be proved that the overthrowing power of the shock is a maximum, greater than anywhere, within or without it—*within*, because there the *direction* of normal movement in the wave is more nearly vertical, and hence less calculated to upset objects *standing* on the ground—and *without*, because the further the shock has travelled away from the Seismic vertical, the more its power (to speak loosely) has decayed. This is the *Meizoseismal circle or curve.* The angle made with the Seismic vertical by a line drawn from any point in this curve at the surface down to the centre of impulse, is for the same conditions constant.

If the impulse or blow has been accompanied by rending or fracture, or the striking or grinding together of hard or rocky masses, or by the rush of vapours or gases, then the *wave of shock* will be accompanied by *waves of sound.* But these latter may or may not travel just at the same rate, or by quite the same wave-paths to the ear of a person upon the surface, as does that of the shock which he feels. Hence there may be Earthquake shocks, with or without sounds, and the shock may be perceived before any sound is heard, or the sounds may precede and herald the shock, as the awful "*bramidos*" generally do the Earthquakes of Mexico.

But to hearers remote from the Seismic vertical, the sounds, if any, will reach their ears not only through the earth, but through a longer or shorter intervening range of air, and hence at very different times and with very different amounts of repercussion and reverberation, although originating in one sound only, as of a single rend, or grind, or explosion.

A remarkable use has been made, for the first time, of the differences in the character of the sounds heard nearly simultaneously, and at about equal distances all round the Seismic vertical, in the Report addressed to the Royal Society of the examination made on the facts of the Neapolitan Earthquake of 1857, by employing them to determine approximately from their varying character the form of the focal surface or cavity, or of the subterranean locus of the centre of effort, —and the method will no doubt hereafter, when more largely and completely applied, yield very important results. Space forbids us, however, here to do more than mention it, and refer to the Report in question.

These, then, are the waves produced by a *single* impulse, and constituting an Earthquake whose *origin is inland.* But should the *origin* be *under the sea,* then at the point passed through by the Seismic vertical and around it, the sea-bottom is, as on land, suddenly upheaved, and again dropped down; or it may be, as by submarine volcano, actually broken up altogether, and steam, lava, and floods of lapilli, and so forth, may be then belched forth under water. In either case there is forced up a volume of water upon the sea's surface just above, or several of these in succession, and as each mass falls again it assumes the horizontal form of a circular liquid wave of translation—and these are propagated outwards over the surface of the sea, like the circles or ring-shaped waves on a pond, when a pebble is dropped into it. The altitude and breadth of these waves depend mainly upon the magnitude of the disturbance of the bottom, and on the depth of water above it; the rate of their propagation outwards has nothing to do directly with elasticity, it is dependent simply upon the square root of the depth of the water traversed by the wave on its surface. If the ocean continued everywhere of the same depth, and the original impulse came from a single point, or circular disc, then the horizontal plan of the crest of any one of these waves would always remain a circle; but the depth varies—and as that part of the expanded circle which is over a deeper part moves on much faster than portions moving over shallow water, or approaching shores—so the circles soon get distorted into various other closed curves, and the original radial direction of translation outwards gets changed to any extent—so that a wave might, without any reflection, even double back upon its original line of progress.

When the long flat swell of such waves, as they are originated on the deep sea, approaches the shores and reaches shoal water, their fronts become steeper and steeper, and they finally roll in upon the shore, as the *great sea waves* of South American and other Earthquakes, so much dreaded wherever they have been once experienced. They are often so large that they only topple over as *breakers* after they have rolled in unbroken masses far inland.

Such was the wave that swept, in one unexpected deluge, thousands of people off the Quay at Messina, and which in some South American Earthquakes have inundated devoted cities like Valparaiso and Callao, with a frowning crest 80 feet in height. Not that the wave while it was far out at sea possessed anything like this altitude,—but just as the Atlantic tide wave,—when constricted in the Bay of Fundy, or in our own Bristol Channel reaches 70 or 40 feet; so does the Earthquake sea-wave rise and get steep in the narrow and shallow waters.

Thus, we see that in an Earthquake whose origin is beneath the sea, there may be a series of waves, all arriving in the following order, differently, and at different times, to an observer standing on the land.

1st. The great Earthquake wave of shock.

2nd. The *forced* sea-wave (of which we have as yet not spoken); it is the roll of water forced up by, and carried along with, the earth-wave, which raises the sea-bottom, and with it the water upon its back as it were, and at its own rate of motion, after it has got into shallow water. This is but occasionally perceptible, and only in great Earthquakes.

3rd. The sound-wave *through the earth*, which may or may not be before.

4th. The sound-wave *through the sea.*

5th. The sound-wave *through the air.*

All these except the second are elastic waves.

6th, and lastly. *The great sea-wave,* or wave of translation, rolls in and completes the catastrophe, often hours after the shock has done its work of destruction ; or portions of it may roll in upon shores that have felt no shock at all. Thus in the great Earthquake at Japan, which a few years ago wrecked a Russian frigate in one of the harbours there, the great sea-wave produced in the deep seas, near those great Islands, hours afterwards, reached the opposite shores of the Pacific, at St. Diego and Francisco, and gave the first intelligence at those places of the disaster that had occurred at the further side of that great ocean.

Space forbids us now to pursue the subject further. At some future opportunity we may be enabled to revert to it ; and to develope the relations between the movements of the elastic-wave particle and the wave's transit to which we have in the preceding pages almost confined our remarks. It remains also to be shown by what methods the position and depth, and even the form and magnitude of the deep-seated focus of an Earthquake, may be ascertained by deciphering, with the help of science, the terrible handwriting left by the destroyer upon the country it has overthrown. To these should be added some description of the *secondary effects* of Earthquakes, in moulding anew the features of the lands they pass over, and how those affect and modify the shocks that reach them. Something, too, might be said as to the distribution of Earthquakes in time and in space upon our Earth's surface ; what are the conditions originating within our planet ; the impulses on which their existence depends ; and, lastly, what is the *function* of Earthquakes, and what uses they fulfil as parts of the great cosmical machine.

LIGHTHOUSE ILLUMINATION BY MAGNETO-ELECTRICITY.

By J. H. Gladstone, Esq., Ph.D., F.R.S.

Anyone who, on a tolerably clear night, has crossed the channel between Folkestone and Boulogne, and remained on deck, must have noticed on the French coast what appeared a brilliant star, now waxing, now waning. It was the light of the far-famed Pharos, on Cape Grisnez. But if he has made the passage within the last eighteen months, his gaze will have been attracted by a still brighter star on the British coast, of a bluish tint, steady and brilliant. This is the Magneto-electric Light at Dungeness, the brightest spark in the world, and one which unites a rare scientific with a practical interest, and may prove only the first lighted of a multitude of similar beacons. I propose to say a few words on the history, production, and merits of this Light.

History.—If we ask the parentage of the Magneto-electric Light, Mr. Frederick Hales Holmes is certainly its father, but, like other beings, it has had two grandfathers—the philosopher who first showed the conducting power of charcoal, and the brilliancy of the light between charcoal terminals of an interrupted galvanic current; and Professor Faraday, who discovered that when a piece of soft iron, surrounded by a coil of metallic wire, was made to pass by the poles of a magnet, an electric current was produced in the wire, which revealed its existence by effecting chemical decompositions, or by giving a spark. This spark, it is true, was barely visible as at first obtained, but it has been exalted into the present Magneto-electric Light.

It appears that in 1853 some large Magneto-electric machines were erected in Paris for producing gas by the decomposition of water, the object of the proprietor being to use this gas for the purposes of combustion; but the scheme failed, the Company that was being formed came to nothing, and the machines were pronounced by leading scientific men to be only expensive toys. Mr. Holmes, however, who was one of the referees, proposed to turn them to account for electro-plating and gilding, and thought it possible that the Electric Light might be produced advantageously by their means. "My propositions," he says, in his evidence before the Royal Commission on Lights, Buoys, and Beacons, "were entirely ridiculed, and the consequence was, that instead of saying that I thought I could do it, I promised to do it by a certain day. On that day, with one of Duboscq's regulators or lamps, I produced the Magneto-electric Light for the first time, but as the machines were ill-constructed for the purpose, and as I had considerable difficulty to make even a temporary adjustment to produce a fitting current, the Light could only be exhibited for a few minutes at a time—say ten or twenty minutes—when the adjustments were entirely displaced by the friction; the rubbing surfaces were worn away. From this time I directed my attention more particularly to the reconstruction of the machines entirely, from the very frame-work upwards, so as to produce the current that I saw necessary for the Electric Light." During this time, it appears that Mr. Holmes, not liking the treatment he received from the French Company, left Paris, and left his imperfect machine there, and it was this very machine which was subsequently used by the French Government in their experiments, and these experiments were carried on by a man who had worked under Mr. Holmes. The inventor next appears in Belgium, continuing his improvements with a new machine, and visited by Admiral (then Captain) Fitzroy, who was commissioned by the Admiralty to go to Brussels, see the Light, and report on it. In February, 1857, Professor Holmes applied to the Trinity Board, and in the following month the Electric Light was exhibited, for several nights, at the experimental lantern* at Blackwall, before the Light Committee and Professor Faraday. In May, an agreement was made for a trial at the South Foreland; but it was not till the 8th December that this experiment at an actual lighthouse was commenced. The Elder Brethren made arrangements for getting observations by the crews of pilot-cutters, masters of light-vessels, and the keepers of neighbouring lighthouses, both on the British and French coasts. Some unforeseen difficulties seem to have arisen, due partly, no doubt, to the novelty of the whole arrangement, but partly also to the complicated optical apparatus in the Lighthouse being suited to a large flame instead of a brilliant point of light, and being ill-adjusted to throw that light to the horizon. All this caused some interruptions in the experiment. M. Reynaud, the Director-General of the French Lighthouses, inspected the Light on April 26, 1859; it was visited by most of the Members of the Royal Commission of Lights, Buoys, and Beacons, including myself, three days afterwards, and on the same day Professor Faraday wrote a Report to the Trinity House. The opinions expressed were so far favourable, that the Elder Brethren desired a further trial of six months, during which time the Light was to be entirely under their own control, Mr. Holmes not being allowed to interfere in any way. The Light was again kindled on August 22, and the experiment happened soon to be exposed to a severe test, as one of the Light-keepers, who had been accustomed to the arrangement of the lamps in the lantern, was suddenly removed, and another took his place without any previous instruction. This man thought the light quite strong enough if he allowed the carbon points to touch, as the lamp then required no attendance whatever, and he could leave it in that way for hours together. On being remonstrated with, he said, "It is quite good enough." Notwithstanding such difficulties as these, the experiment was considered satisfactory, but it was discontinued at the South Foreland, for the cliffs there are marked by a double light, and the electric spark was so much brighter than the oil flames in the other house, that there was no small danger of its being seen alone in thick weather, and thus fatally misleading some unfortunate vessel.

Then occurred a period of two years, consumed partly in coming

* The room with glass sides, from which the light is exhibited at the top of a lighthouse, is called a "lantern."

to the decision that the Magno-electric Light was to be exhibited at Dungeness, and partly in fitting up the lighthouse there (which by the way had been cracked by lightning) for the reception of its new occupant.

It was not deemed desirable to trust the illumination of that headland entirely to the Electric Light, hence the old apparatus was retained, and the oil-lamp has always been kept ready for use in case of necessity. A supplementary lantern was therefore constructed on the top of the ordinary one, and in this the electric lamp was fixed, and surrounded by a small combination of lenses and prisms made expressly for it by Messrs. Chance, of Birmingham. In the meantime Mr. Holmes had considerably improved his lamp by borrowing an idea from an arrangement devised by a M. Serrin. At length, in February, 1862, this lamp was lit at Dungeness, but it was extinguished on account of the necessity of instructing fresh lighthouse keepers, who had to take charge of the apparatus, and it was not till the 6th of June that the brilliant star shone permanently on our Southern coast.

In the meantime, the French have not been indifferent or idle. When the Royal Commission visited Paris, the Lighthouse authorities were found experimenting with a comparatively small machine, and had clearly not overcome the difficulty of maintaining the charcoal points at a proper distance. But they persevered, and last July there was published in the 'Moniteur Universel' a Report by M. Reynaud to the Minister of Commerce and Public Works, in which he expressed a most favourable opinion of the Electric Light, and the Minister gave an order for two Electro-magnetic machines to be placed in the double Lighthouse of the Cap de la Hève, near Havre. Thus France is following England in the adoption of this improvement in coast lights, just as, years ago, Great Britain followed France in the use of the Dioptric system of illumination.

It is possible that some other nations may not be behind the French. The Dutch Government contemplate placing an Electric Light at Scheveningen, and a second one at Texel. The Lighthouse system in the empire of Brazil is excellent, and they have long had an eye on the Electric Light. Sweden is on the alert; and inquiries also have been made respecting its management and cost by the Imperial Academy of Vienna.

Apparatus.—Many readers will be familiar with the apparatus both of Mr. Holmes and of M. Berlioz, from having examined them at the International Exhibition last year. It would be very difficult to describe them without drawings, but the following may give a sufficiently good general idea. In the apparatus at Dungeness, the power that produces the light is resident in 120 permanent magnets, of about 50lbs. each, ranged on the periphery of two large wheels. This power is called into action by a steam-engine, with Cornish boilers, of about three-horse power, which causes a series of 160 soft iron cores surrounded by coils of wire to rotate past the magnets. The small streams of Electricity thus generated are collected together into one stream, and by a special piece of apparatus called a Commutator the alternate positive and negative currents are all brought into one direction. The whole power is then conveyed by a thick wire from the engine-house to the lighthouse tower, and up into the centre of the illuminating apparatus. There it passes between two charcoal points, producing thus a most brilliant and continuous spark. The "Lamp," or "Regulator," is so contrived that by means of a balance arrangement and a magnet, round which the wire coils, the charcoal points are kept always at a proper distance apart.

At sunset the machine is started, making about 100 revolutions per minute; and the attendant has only to draw two bolts in the lamp when the power thus spun in the engine-room bursts into light of full intensity. It now requires little or no thought for three hours and a half, when the charcoal points being consumed the lamp must be changed, and this is done without extinguishing the light, for it is the kindling of the second lamp that puts out the first. There are always several lamps ready at Dungeness in case of accident, and everything is kept in duplicate.

The French machine is composed of 56 magnets distributed in 7 vertical equidistant planes, upon the angles of an octagonal prism. The maximum of intensity is obtained when the machine turns 350 or 400 times per minute, and the direction of the current is then reversed nearly 6,000 times per minute. There is no Commutator employed, and the alternate currents are not brought into one.

Merits and Demerits.—In favour of the Electric Apparatus, it may be stated without any fear of contradiction that the light is vastly more intense than that produced from the most powerful oil-lamp, or any practicable number of argand burners. In truth that now shining at Dungeness is the most brilliant light in existence. The following statement will illustrate this. Professor Faraday says of it, when at the South Foreland, "During the daytime I compared the intensity of the light with that of the sun, that is, it was placed before and by the side of the sun, and both looked at through dark glasses; its light was as bright as that of the sun, but the sun was not at its brightest." No other light in existence would have stood that test. Again, he describes an experiment at Dungeness:—"Arrangements were made on shore, by which observations could be made at sea about five miles off on the relative light of the Electric lamp, and the metallic reflectors with their argand oil lamps—[the light formerly used]—for either could be shown alone, or both together. . . . . The combined effect was a glorious light up to the five miles; then, if the Electric light was extinguished, there was a great falling off in the effect; though, after a few moments' rest to the eye, it was seen that the oil-lamps and reflectors were in their good and proper state. On the other hand, when the Electric light was restored, the glory rose to its first high condition. Then, whilst both were in action, the reflectors were shaded, and the Electric light left alone; but the naked eye could see no sensible *diminution;* nor when the reflectors were returned into effectual use, could it see any sensible *addition* to the whole light power, though the telescope showed that the alteration in the lantern had taken place at the right time." M. Reynaud estimates the usual intensity of the light at from 180 to 190 standard Carcel burners.

This superiority of brightness is of practical service only in thick weather, for if the air be clear an ordinary first-class light under the old system answers every purpose of the mariner, and in fog no light is of any avail; but it scarcely requires demonstration that in certain intermediate states of the atmosphere, the brighter light will penetrate the haze, rain, or snow to a distance at which the other is perfectly invisible. There is nothing in the nature of the rays emitted to prevent its doing so, for when submitted to spectral analysis, the Electric light is found to contain every ray that the oil-flame does, and others beside. The returns of neighbouring lighthouse keepers, and of the masters of two of the lightships at the Goodwin Sands, during the experiment at the South Foreland, show this to be actually the case, and similar testimony is borne by the masters of passing vessels, the commanders of the Channel Steam Packets, and the pilots who frequent the neighbouring seas.

The peculiar bluish colour of the light as seen from a distance is another advantage, by distinguishing it from ships' lights, or lamps on shore; and practically this is a great object. Of course, it may be made red or green, or any other tint, by coloured glasses. Indeed it is peculiarly adapted for such a purpose. As the light can be interrupted and immediately rekindled with full intensity at pleasure, this light offers facilities for signaling which no other does. Each lighthouse might be made to repeat its own number all night long, if that were thought desirable. Another advantage is well stated in the words of Professor Faraday:—" In cases where the light is from lamp flames fed by oil, no increase of light at or near the focus or foci of the apparatus is possible beyond a certain degree, because of the size of the flames; but in the Electric lamp, any amount of the light may be accumulated at the focus, and sent abroad at, of course, an increased expense. In consequence of the evolution of the light in so limited a focal space, it may be directed seaward, diverging either more or less, or in a vertical or horizontal direction at pleasure, with the utmost facility. The enormous shadow under the light, produced by the oil-flame burner, which absorbs and renders useless the descending rays to a very large extent, does not occur in the Magneto-electric lamp; all the light proceeding in that direction is turned to account. The optical part of the arrangement, whether dioptric or reflecting, might be very small in comparison with those in use:" and, indeed, it is so at Dungeness. As there is always an extra steam-engine and machinery on the premises, and ready for work, the power, and the consequent light between the charcoal points, might at any time be doubled, if the state of the atmosphere seemed to require it.

It has already been remarked that in fog no light, however powerful, is of much avail, and public attention is now being directed to the necessity of improving our fog signals. It has been well observed in M. Reynaud's Report, "During foggy weather the supplementary steam-engine might be employed in playing sonorous instruments, which would carry sound to a much greater distance than the bells to which we have recourse at present."

Against the advantages attending the use of this Electric light must be set the greater complexity of the instrument, and the consequent greater chance of derangement, or rather the necessity of providing lighthouse keepers of a superior order, and an engineer to inspect the machinery and keep it in repair. This demand for superior workmen is a difficulty we generally have to encounter in perfecting our engines either of peace or war.

The relative expense of the Magneto-electric light and the Fresnel lamp is a consideration that must not be overlooked, though it should not be allowed too much weight when we are dealing with the safety of valuable cargoes and priceless human lives. The original outlay in machinery for the Electric light is very large, but there must be set against this a considerable diminution in the cost of the apparatus used for directing the rays where they are wanted. The working expense consists of the coals burnt, the charcoal points used up, and the wear of the machinery, all of which perhaps scarcely exceeds the cost of oil under the old system. The magnets are said rather to increase in strength than to diminish by use. The salary of an engineer is a more serious item, but the expense may be greatly reduced by appointing one engineer to several lighthouses, if the electric system become common. Mr. Holmes estimates the working expenses of the electric apparatus as compared with the oil lamp, at about 400 against 290. The French estimate is, "Abstracting the expenses of the first establishment, it will be found that while the expenses of the annual maintenance of a lighthouse of the first order fed with colza oil rise to 9,421 francs 75 centimes, those of the same lighthouse illuminated by electricity would be 12,240 francs." Again, "The annual expense will be increased 29 per cent. in lighthouses of the first order, but it will have the effect of rendering the luminous intensity at least fivefold greater."

It has been objected that the light is too bright, dazzling the mariner and misleading him as to its distance, but experience will soon remove this source of error, and it is hard to understand how the light can produce any dazzling effect, unless exhibited at the head of a pier close alongside of which the mariner must steer his way. But for harbour lights it is not required. Its proper place is on the prominent points of the coast which are used as landfalls by vessels, and unless objections present themselves in the future which are as yet unknown, we may confidently anticipate that each of these headlands will in time be marked by its brilliant Electric light.

ON THE APPLICATION OF THE PRINCIPLE OF "CONSERVATION OF FORCE" TO PHYSIOLOGY.*

Part I. *The Relations of Light and Heat to the Vital Forces of Plants.*

By William B. Carpenter, M.D., F.R.S., F.L.S., F.G.S.

In every period of the history of Physiology, attempts have been made to identify all the forces acting in the Living body with those operating in the Inorganic universe. Because muscular force, when brought to bear on the bones, moves them according to the mechanical laws of lever-action, and because the propulsive power of the heart drives the blood through the vessels according to the rules of hydraulics, it has been imagined that the movements of living bodies may be explained on Physical principles;—the most important consideration of all, namely, the source of that contractile power which the living muscle possesses, but which the dead muscle (though having the same chemical composition) is utterly incapable of exerting, being altogether left out of view. So, again, because the digestive process, whereby food is reduced to a fit state for absorption, as well as the formation of various products of the decomposition that is continually taking place in the living body, may be imitated in the laboratory of the Chemist; it has been supposed that the appropriation of the nutriment to the production of the living organized tissues of which the several parts of the body are composed, is to be regarded as a chemical action,—as if any combination of albumen and gelatine, fat and starch, salt and bone-earth, could make a living Man without the constructive agency inherent in the germ from which his bodily fabric is evolved.

Another class of reasoners have cut the knot which they could not untie, by attributing all the actions of living bodies for which physics and chemistry cannot account, to a hypothetical "Vital Principle"; a shadowy agency that does everything in its own way, but refuses to be made the subject of scientific examination; like the "od-force" or the "spiritual power" to which the lovers of the marvellous are so fond of attributing the mysterious movements of turning and tilting tables.

A more scientific spirit, however, prevails among the best Physiologists of the present day; who, whilst fully recognizing the fact that many of the phenomena of living bodies can be accounted for by the agencies whose operation they trace in the world around, separate into a distinct category—that of *vital* actions—such as appear to differ altogether *in kind* from the phenomena of Physics and Chemistry; and seek to determine, from the study of the conditions under which these present themselves, the *laws* of their occurrence.

In the prosecution of this inquiry, the Physiologist will find it greatly to his advantage to adopt the method of philosophizing which distinguishes the Physical Science of the present from that of the past

* To be concluded in our next Number.

generation; that, namely, which, whilst fully accepting the logical definition of the *cause* of any phenomenon, as "the antecedent, or the concurrence of antecedents on which it is invariably and unconditionally consequent" (Mill), draws a distinction between the *dynamical* and the *material* conditions; the former supplying the *power* which does the work, whilst the latter affords the *instrumental means* through which that power operates. Thus, if we inspect a Cotton-factory in full action, we find it to contain a vast number of machines, many of them but repetitions of one another, but many, too, presenting the most marked diversities in construction, in operation, and in resultant products. We see, for example, that one is supplied with the raw material, which it cleans and dresses; that another receives the cotton thus prepared, and "cards" it so as to lay its fibres in such an arrangement as may admit of its being spun; that another series, taking up the product supplied by the carding machine, twists and draws it out into threads of various degrees of fineness; and that this thread, carried into a fourth set of machines, is woven into a fabric which may be either plain, or variously figured, according to the construction of the loom. In every one of these dissimilar operations, the *force* which is immediately concerned in bringing about the result, is one and the same; and the variety of its products is dependent solely on the diversity of the material instruments through which it operates. Yet these arrangements, however skilfully devised, are utterly valueless without the force which brings them into play.* All the elaborate mechanism, the triumph of human ingenuity in devising, and of skill in constructing, is as powerless as a corpse, without the *vis viva* which alone can animate it. The giant stroke of the steam-engine, or the majestic revolution of the water-wheel, gives the required impulse; and the vast apparatus which was the moment previously in a state of death-like inactivity, is aroused to all the energy of its wondrous life,—every part of its complex organization taking upon itself its peculiar mode of activity, and evolving its own special product, in virtue of the share it receives of the one general force distributed through the entire aggregate of machinery.

But if we carry back our investigation a stage further, and inquire into the origin of the force supplied by the steam-engine or the water-wheel, we soon meet with a new and most significant fact. At our first stage, it is true, we find only the same mechanical force acting through a different kind of instrumentality; the strokes of the piston of the steam-engine being dependent upon the elastic force of the vapour of water, whilst the revolution of the water-wheel is maintained by the downward impetus of water *en masse*. But to what antecedent dynamical agency can we trace *these* forces? That agency, in each case, is Heat; a force altogether dissimilar in its ordinary manifestations to the force which produces sensible motion, yet capable of being in turn converted into it and generated by it. For it is from the Heat applied beneath the boiler of the steam-engine, that the non-elastic liquid contained in it derives all that potency as elastic

* In going through a manufacturing town, I have often been struck with the announcements of "Power to Let."

vapour, which enables it to overcome the vast mechanical resistance that is set in opposition to it. And, in like manner, it is the heat of the solar rays which pumps up terrestrial waters in the shape of vapour, and thus supplies to Man a perennial source of new power in their descent by the force of gravity to the level from which they have been raised.*

The power of the steam-engine, indeed, is itself derived more remotely from those same rays; for the Heat applied to its boilers is but the expression of the chemical change involved in combustion; that combustion is sustained either by the wood which is the product of the vegetative activity of the present day, or by the coal which represents the vegetative life of a remote geological epoch; and that vegetative activity, whether present or past, represents an equivalent amount of Solar Light and Heat, used up in the decomposition of the carbonic acid of the atmosphere by the instrumentality of the growing plant.† Thus in either case we come, directly or indirectly, to Solar Radiation as the mainspring of our mechanical power; the *vis viva* of our whole microcosm. Modern physical inquiry ventures even one step further, and seeks the source of the Light and Heat of the Sun itself. Are these, as formerly supposed, the result of combustion; or are they, as surmised by Mayer and Thomson, the expression of the motive power continually generated in the fall of aërolites towards the Sun, and as continually annihilated by their impact on its surface? Leaving the discussion of this question to Physical Philosophers, I proceed now to my own proper subject.

It is now about twenty years since Dr. Mayer first broadly announced, in all its generality, the great principle now known as that of Conservation of Force; as a necessary deduction from two axioms or essential truths—*ex nihilo nil fit*, and *nil fit ad nihilum*—the validity of which no true philosopher would ever have theoretically questioned, but of which he was (in my judgment) the first to appreciate the full practical bearing. Thanks to the labours of Faraday, Grove, Joule, Thomson, and Tyndall, to say nothing of those of Helmholtz and other distinguished Continental savans, the great doctrine expressed by the term "Conservation of Force" is now amongst the best established generalizations of Physical Science; and every thoughtful Physiologist must desire to see the same course of inquiry thoroughly pursued in regard to the phenomena of living bodies. This ground was first broken by Dr. Mayer in his remarkable treatise, 'Die Organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel' ('On Organic Movement in its relation to Material Changes,' Heilbronn, 1845); in which he distinctly set forth the principle that the source of all changes in the living Organism, animal as well as vegetable, lies in the forces acting upon it *from without;* whilst the changes in its own composition brought about by

* See on this subject the recent admirable address of Sir William Armstrong, at the Meeting of the British Association at Newcastle.

† This was discerned by the genius of George Stephenson, before the general doctrine of the Correlation of Forces had been given to the world by Mayer or Grove.

these agencies he considers to be the immediate source of the forces which are generated by it. In treating of these forces, however, he dwells chiefly on the production of Motion, Heat, Light, and Electricity by living bodies; touching more slightly upon the phenomena of Growth and Development, which constitute, in the eye of the Physiologist, the distinct province of vitality. In a Memoir of my own "On the Mutual Relations of the Vital and Physical Forces," published in 'The Philosophical Transactions for 1850,'* I aimed to show that the general doctrine of the "Correlation of the Physical Forces," propounded by Mr. Grove, was equally applicable to those Vital forces, which must be assumed as the moving powers in the production of purely Physiological phenomena; these forces being generated in living bodies by the transformation of the Light, Heat, and Chemical Action supplied by the world around, and being given back to it again, either during their life or after its cessation, chiefly in Motion and Heat, but also to a less degree in Light and Electricity. This Memoir attracted but little attention at the time, being regarded, I believe, as too speculative; but I have since had abundant evidence that the minds of thoughtful Physiologists as well as Physicists are moving in the same direction; and as the progress of science since the publication of my former Memoir would lead me to present some parts of my scheme of doctrine in a different form,† I venture again to bring it before the public in the form of a *sketch* (I claim for it no other title) of the aspect in which the application of the principle of the "Conservation of Force" to Physiology now presents itself to my mind.

If, in the first place, we inquire what it is that essentially distinguishes Vital from every kind of Physical activity, we find this distinction most characteristically expressed in the fact that a germ endowed with Life developes itself into an Organism of a type resembling that of its parent; that this organism is the subject of incessant changes, which all tend in the first place to the evolution of its typical form, and subsequently to its maintenance in that form, notwithstanding the antagonism of Chemical and Physical agencies which are continually tending to produce its disintegration; but that as its term of existence is prolonged, its conservative power declines so as to become less and less able to resist these disintegrating forces, to which it finally succumbs, leaving the organism to be resolved by their agency into the components from which its materials were originally drawn. The history of a living organism, then, is one of *incessant change;* and the conditions of this change are to be found

* At this date the labours of Dr. Mayer were not known either to myself or (so far as I am aware) to anyone else in this country, save the late Dr. Baly, who, a few months after the publication of my Memoir, placed in my hands the pamphlet 'Die Organische Bewegung;' to which I took the earliest opportunity in my power of drawing public attention in 'The British and Foreign Medico-Chirurgical Review' for July, 1851, p. 237.

† I have especially profited by a memoir on 'The Correlation of Physical, Chemical, and Vital Force, and the Conservation of Force in Vital Phenomena,' by Prof. Le Conte (of South Carolina College), in Silliman's 'American Journal' for Nov. 1859, reprinted in 'The Philosophical Magazine' for 1860.

partly in the organism itself, and partly in the external agencies to which it is subjected. That condition which is inherent in the organism, being derived hereditarily from its progenitors, may be conveniently termed its *germinal capacity:* its parallel in the Inorganic world being that fundamental difference in properties which constitutes the distinction between one substance, whether elementary or compound, and another; in virtue of which each "behaves" in its own characteristic manner when subjected to new conditions.

Thus, although there may be nothing in the aspect or sensible properties of the germ of a Polype to distinguish it from that of a Man, we find that each developes itself, if the requisite conditions be supplied, into its typical form, *and no other;* if the developmental conditions required by either be not supplied, we do not find a different type evolved, but no evolution at all takes place.*

Now the difference between a being of *high* and a being of *low* organization essentially consists in this;—that in the latter the constituent parts of the fabric evolved by the process of growth from the original germ are similar to each other in structure and endowments; whilst in the former they are progressively differentiated with the advance of development, so that the fabric comes at last to consist of a number of *organs* or instruments more or less dissimilar in structure, composition, and endowments. Thus in the lowest forms of Vegetable life, the primordial germ multiplies itself by duplicative subdivision (*a*, *b*, *c*, *d*) into an apparently unlimited number of cells, each of them similar to every other, and capable of maintaining its existence independently of them. And in that lowest Rhizopod type of Animal life, the knowledge of which is among the most remarkable fruits of modern biological research, "the Physiologist has a case in which those vital operations which he is elsewhere accustomed to see carried on by an elaborate apparatus, are performed without any special instruments whatever; a little particle of apparently homogeneous jelly changing itself into a greater variety of forms than the fabled Proteus, laying hold of its food with-

* It is quite true that among certain of the lower tribes both of Plants and Animals—especially the *Fungi* and *Entozoa*—similar germs may develope themselves into very dissimilar forms, according to the conditions under which they are evolved; but such diversities are only of the same kind as those which manifest themselves among *individuals* in the higher Plants and Animals, and only show that in the types in question there is a less close conformity to one pattern. Neither in these groups, nor in that group of *Foraminifera* in which I have been led to regard the range of variation as peculiarly great, does any tendency ever show itself to the assumption of the characters of any group fundamentally dissimilar.

out members, swallowing it without a mouth, digesting it without a stomach, appropriating its nutritious material without absorbent vessels or a circulating system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves, propagating itself without genital apparatus, and not only this, but in many instances forming shelly coverings of a symmetry and complexity not surpassed by those of any testaceous animals,"* whilst the mere separation of a fragment of this jelly is sufficient to originate a new and independent organism, so that any number of these beings may be produced by the successive detachment of such particles from a single Rhizopod, each of them retaining (so far as we have at present the means of knowing) the characteristic endowments of the stock from which it was an offset.

When, on the other hand, we watch the evolution of any of the higher types of Organization, whether Vegetable or Animal, we observe that although in the first instance the primordial cell multiplies itself by duplicative subdivision into an aggregation of cells which are apparently but repetitions of itself and of each other, this homogeneous extension has in each case a definite limit, speedily giving place to a structural differentiation which becomes more and more decided with the progress of development; until, in that most heterogeneous of all types—the Human Organism—no two parts are precisely identical, except those which correspond to each other on the opposite sides of the body. With this structural differentiation is associated a corresponding differentiation of function; for whilst in the Life of the most highly developed and complex organism we witness no act which is not foreshadowed, however vaguely, in that of the lowest and simplest, yet we observe in it that same "division of labour" which constitutes the essential characteristic of the highest grade of Civilization. For in what may be termed the elementary form of Human Society, in which every individual relies upon himself alone for the supply of all his wants, no greater result can be obtained by the aggregate action of the entire community than its mere maintenance; but as each individual selects a special mode of activity for himself, and aims at improvement in that speciality, he finds himself attaining a higher and yet higher degree of aptitude for it; and this specialization tends to increase as opportunities arise for new modes of activity, until that complex fabric is evolved which constitutes the most developed form of the Social State, wherein every individual finds the work—mental or bodily—for which he is best fitted, and in which he may reach the highest attainable perfection; while the mutual dependence of the whole (which is the necessary result of this specialization of parts) is such that every individual works for the benefit of all his fellows, as well as for his own. As it is only in such a state of society that the greatest triumphs of human ability become possible, so it is only in the most differentiated types of Organization that Vital Activity can present its highest manifestations. In the one case as in the other does the result depend upon a process of gradual *development*, in which, under the

* See the Author's 'Introduction to the Study of the Foraminifera,' published by the Ray Society, 1862: Preface, p. vii.

influence of agencies whose nature constitutes a proper object of scientific inquiry, that *most general* form in which the fabric—whether Corporeal or Social—originates, evolves itself into that *most special* in which its development culminates.

But notwithstanding the wonderful diversity of structure and of endowments which we meet with in the study of any complex Organism, we encounter a harmonious unity or co-ordination in its entire aggregate of actions, which is yet more wonderful. It is this harmony or co-ordination, whose tendency is to the conservation of the organism, that the state of Health or Normal Life essentially consists. And the more profound our investigation of its conditions, the more definite becomes the conclusion to which we are led by the study of them,—that it is fundamentally based on the common origin of all these diversified parts in the same germ, the vital endowments of which, equally diffused throughout the whole fabric in those lowest forms of organization in which every part is but a repetition of every other, are differentiated in the highest amongst a variety of organs, acquiring in virtue of this differentiation a much greater intensity.

Thus, then, we may take that mode of Vital Activity which manifests itself in the evolution of the germ into the complete organism repeating the type of its parent, and the subsequent maintenance of that organism in its integrity,—in the one case, as in the other, at the expense of materials derived from external sources,—as the most universal and most fundamental characteristic of Life; and we have now to consider the nature and source of the *Force* or *Power* by which that evolution is brought about. The prevalent opinion has until lately been, that this power is inherent in the germ; which has been supposed to derive from its parent not merely its material substance, but a *nisus formativus*, *Bildungstrieb*, or *germ-force*, in virtue of which it builds itself up into the likeness of its parent, and maintains itself in that likeness until the force is exhausted, at the same time imparting a fraction of it to each of its progeny. In this mode of viewing the subject, all the organizing force required to build up an Oak or a Palm, an Elephant or a Whale, must be concentrated in a minute particle, only discernible by microscopic aid; and the aggregate of all the germ-forces appertaining to the descendants, however numerous, of a common parentage, must have existed in their original progenitors. Thus, in the case of the successive viviparous broods of *Aphides*, a germ-force capable of organizing a mass of living structure, which would amount (it has been calculated)* in the tenth brood to the bulk of 500 millions of stout men, must have been shut up in the single individual, weighing perhaps the 1-1000th of a grain, from which the first brood was evolved. And in like manner, the germ-force which has organized the bodies of all the individual men that have lived from Adam to the present day, must have been concentrated in the body of their common ancestor. A more complete *reductio ad absurdum* can scarcely be brought against any hypothesis; and we may consider it proved that, in some way or

* See Prof. Huxley on the "Agamic Reproduction of Aphis," in 'Linn. Trans.,' vol. xxii. p. 215.

other, fresh organizing force is constantly being supplied *from without* during the whole period of the exercise of its activity.

When we look carefully into the question, however, we find that what the *germ* really supplies is not the force, but the *directive agency;* thus rather resembling the control exercised by the superintendent builder who is charged with the working out the design of the architect, than the bodily force of the workmen who labour under his guidance in the construction of the fabric. The actual constructive force, as we learn from an extensive survey of the phenomena of life, is supplied by Heat; the influence of which upon the rate of growth and development, both animal and vegetable, is so marked as to have universally attracted the attention of Physiologists: who, however, have for the most part only recognized in it a *vital stimulus* that calls forth the latent power of the germ, instead of looking upon it as itself furnishing the power that does the work. It has been from the narrow limitation of the area over which physiological research has been commonly prosecuted, that the intimacy of this relationship between Heat and the Organizing force has not sooner become apparent. Whilst the vital phenomena of Warm-blooded Animals, which possess within themselves the means of maintaining a constant temperature, were made the sole, or at any rate the chief, objects of study, it was not likely that the inquirer would recognize the full influence of external heat in accelerating, or of cold in retarding, their functional activity. It is only when the survey is extended to Cold-blooded Animals, and to Plants, that the immediate and direct relation between Heat and Vital Activity, as manifested in the rate of growth and development, or of other changes peculiar to the living body, is unmistakably manifested. To some of those phenomena which afford the best illustrations of the mode in which Heat acts upon the living organism, attention will now be directed.

Commencing with the Vegetable kingdom, we find that the operation of Heat as the "motive power," or dynamical agency, to which the phenomena of growth and development are to be referred, is peculiarly well seen in the process of Germination. The seed consists of an embryo which has already advanced to a certain stage of development, and of a store of nutriment laid up as the material for its further evolution; and in the fact that this evolution is carried on at the expense of organic compounds already prepared by extrinsic agency, until (the store of these being exhausted) the young plant is sufficiently far advanced in its development to be able to elaborate them for itself, the condition of the germinating embryo resembles that of an Animal. Now the seed may remain (under favourable circumstances) in a state of absolute inaction during an unlimited period. If secluded from the free access of air and moisture, and kept at a low temperature, it is removed from all influences that would on the one hand occasion its disintegration, or on the other would call it into active life. But when again exposed to air and moisture, and subjected to a higher temperature, it either germinates or decays, according as the embryo it contains has or has not preserved its vital endowments—a question which only experiment can resolve. The process of germination is by no means a simple one. The nutriment stored up in the seed is in great part in the condition of insoluble starch; and this must be brought into a soluble form before it can be appropriated by the embryo. The metamorphosis is effected by the agency of a ferment termed *diastase;* which is laid up in the immediate neighbourhood of the embryo, and which, when brought to act on starch, converts it in the first instance into soluble dextrine, and then (if its action be continued) into sugar. The dextrine and sugar, combined with the albuminous and oily compounds also stored up in the seed, form the "protoplasm" which is the substance immediately supplied to the young plant as the material of its tissues; and the conversion of this protoplasm into various forms of organized tissue, which become more and more differentiated as development advances, is obviously referable to the vital activity of the germ. Now it can be very easily shown experimentally that the *rate of growth* in the germinating embryo is so closely related (within certain limits) to the amount of Heat supplied, as to place its dependence on that agency beyond reasonable question; so that we seem fully entitled to say that Heat, acting through the germ, supplies the constructive force or power by which the Vegetable fabric is built up.* But there appears to be another source of that power in the seed itself. In the conversion of the insoluble starch of the seed into sugar, and probably also in a further metamorphosis of a part of that sugar, a large quantity of carbon is eliminated from the seed by combining with the oxygen of the air so as to form carbonic acid; this combination is necessarily attended with a disengagement of heat, which becomes very sensible when (as in malting) a large number of germinating seeds are aggregated together; and it cannot but be regarded as probable that the heat thus evolved within the seed concurs with that derived from without, in supplying to the germ the force that promotes its evolution.

The condition of the Plant which has attained a more advanced stage of its development differs from that of the germinating embryo essentially in this particular, that the organic compounds which it requires as the materials of the extension of the fabric are formed by itself, instead of being supplied to it from without. The tissues of the coloured surfaces of the leaves and stems, when acted on by light, have the peculiar power of generating—at the expense of carbonic acid, water, and ammonia—various ternary and quaternary organic compounds, such as chlorophyll, starch, oil, and albumen; and of the compounds thus generated, some are appropriated by the constructive force of the Plant (derived from the heat with which it is supplied) to the formation of new tissues; whilst others are stored up in the cavities of those tissues, where they ultimately serve either for the evolution

* The effect of Heat is doubtless manifested very differently by different seeds; such variations being partly *specific*, partly *individual*. But these are no greater than we see in the inorganic world; the increment of temperature and the augmentation of bulk exhibited by different substances when subjected to the same absolute measure of heat, being as diverse as the substances themselves. The whole process of "malting," it may be remarked, is based on the regularity with which the seeds of a particular species may be at any time forced to a definite rate of germination by a definite increment of temperature.

of parts subsequently developed, or for the nutrition of animals which employ them as food. Of the source of those peculiar affinities by which the components of the starch, albumen, &c., are brought together, we have no right to speak confidently; but looking to the fact that these compounds are not produced in any case by the direct union of their elements, and that a decomposition of binary compounds seems to be a necessary antecedent of their formation, it is scarcely improbable that, as suggested by Prof. Le Conte (*op. cit.*), that source is to be found in the chemical forces set free in the preliminary act of decomposition, in which the elements would be liberated in that "nascent condition" which is well known to be one of peculiar energy.

The influence of Light, then, upon the Vegetable organism appears to be essentially exerted in bringing about what may be considered a higher mode of chemical combination between oxygen, hydrogen, and carbon, with the addition of nitrogen in certain cases; and there is no evidence that it extends beyond this. That the appropriation of the materials thus prepared, and their conversion into organized tissue in the operations of growth and development, are dependent on the agency of Heat, is just as evident in the stage of maturity as in that of germination. And there is reason to believe, further, that an additional source of organizing force is to be found in the retrograde metamorphosis of organic compounds that goes on during the whole life of the plant; of which metamorphosis the expression is furnished by the production of carbonic acid. This is peculiarly remarkable in the case of the *Fungi*, which, being incapable of forming new compounds under the influence of light, are entirely supported by the organic matters they absorb, and which in this respect correspond on the one hand with the germinating embryo, and on the other with Animals. Such a decomposition of a portion of the absorbed material is the only conceivable source of the large quantity of carbonic acid they are constantly giving out; and it would not seem unlikely that the force supplied by this retrograde metamorphosis of the superfluous components of their food, which fall down (so to speak) from the elevated plane of "proximate principles" to the lower level of comparatively simple binary compounds, supplies a force which raises another portion to the rank of living tissue; thus accounting in some degree for the very rapid growth for which this tribe of Plants is so remarkable. This exhalation of carbonic acid, however, is not peculiar to Fungi and germinating embryos; for it takes place during the whole life of Flowering Plants, both by day and by night, in sunshine and in shade, and from their green as well as from their dark surfaces; and it is not improbable that, as in the case of the Fungi, its source lies partly in the organic matters absorbed; recent investigations* having rendered it probable that Plants really take up and assimilate soluble *humus*, which, being a more highly carbonized substance than starch, dextrine, or cellulose, can only be converted into compounds of the latter kind by parting with some of its carbon. But it may also take

* See the Memoir of M. Risler, "On the Absorption of Humus," in the 'Bibliothèque Universelle,' N. S. 1858, tom. i. p. 305.

place at the expense of compounds previously generated by the plant itself, and stored up in its tissues; of which we seem to have an example in the unusual production of carbonic acid which takes place at the period of flowering, especially in such plants as have a fleshy disk or receptacle containing a large quantity of starch; and thus, it may be surmised, an extra supply of force is provided for the maturation of those generative products, whose preparation seems to be the highest expression of the vital power of the Vegetable organism.

The entire aggregate of organic compounds contained in the vegetable tissues, then, may be considered as the expression not merely of a certain amount of the *material elements*, oxygen, hydrogen, carbon, and nitrogen derived (directly or indirectly) from the water, carbonic acid, and ammonia of the atmosphere, but also of a certain amount of *force* which has been exerted, in raising these from the lower plane of simple binary compounds to the higher level of complex "proximate principles;" whilst the portion of these actually converted into organized tissue may be considered as the expression of a further measure of force, which, acting under the directive agency of the germ, has served to build up the fabric in its characteristic type. This *constructive* action goes on during the whole Life of the Plant, which essentially manifests itself either in the extension of the original fabric (to which in many instances there seems no determinate limit), or in the production of the germs of new and independent organisms. —It is interesting to remark that the development of the more permanent parts involves the successional decay and renewal of parts whose existence is temporary. The "fall of the leaf" is the effect, not the cause, of the cessation of that peculiar functional activity of its tissues, which consists in the elaboration of the nutritive material required for the production of wood. And it would seem as if the duration of their existence stands in an inverse ratio to the energy of their action; the leaves of "evergreens," which are not cast off until the appearance of a new succession, effecting their functional changes at a much less rapid rate than do those of "deciduous" trees, whose term of life is far more brief.

Thus the final cause or purpose of the whole Vital Activity of the Plant, so far as the *individual* is concerned, is to produce an indefinite extension of the dense, woody, almost inert, but permanent portions of the fabric, by the successional development, decay, and renewal of the soft, active, and transitory cellular parenchyma; and, according to the principles already stated, the descent of a portion of the materials of the latter to the condition of binary compounds, which is manifested in the largely increased exhalation of carbonic acid that takes place from the leaves in the later part of the season, comes to the aid of external Heat in supplying the force by which another portion of those materials is raised to the condition of organized tissue. —The vital activity of the Plant, however, is further manifested in the provision made for the propagation of its race by the production of the germs of new individuals; and here, again, we observe that whilst a higher temperature is usually required for the development of the flower, and the maturation of the seed, than that which suffices to sustain the ordinary processes of vegetation, a special provision appears to be made in some instances for the evolution of force in the sexual apparatus itself, by the retrograde metamorphosis of a portion of the organic compounds prepared by the previous nutritive operations. This seems the nearest approach presented in the Vegetable organism, to what we shall find to be an ordinary mode of activity in the Animal. That the performance of the generative act involves an extraordinary expenditure of vital force, appears from this remarkable fact, that blossoms which wither and die as soon as the ovules have been fertilized, may be kept fresh for a long period if fertilization be prevented.

The decay which is continually going on during the life of a Plant restores to the Inorganic world, in the form of carbonic acid, water, and ammonia, a part of the materials drawn from it in the act of vegetation; and a reservation being made of those Vegetable products which are consumed as food by Animals, or which are preserved (like timber, flax, cotton, &c.) in a state of permanence, the various forms of decomposition which take place after death complete that restoration. But in returning, however slowly, to the condition of water, carbonic acid, ammonia, &c., the constituents of Plants give forth an amount of Heat equivalent to that which they would generate by the process of ordinary combustion; and thus they restore to the inorganic world not only the *materials* but the *forces*, at the expense of which the Vegetable fabric was constructed. It is for the most part only in the humblest Plants, and in a particular phase of their lives, that such a restoration takes place in the form of *motion;* this motion being, like growth and development, an expression of the vital activity of the "zoospores" of Algæ, and being obviously intended for their dispersion.

Hence we seem justified in affirming that the Correlation between Heat and the Organizing force of Plants is not less intimate than that which exists between Heat and Motion. The special attribute of the Vegetable germ is its power of utilizing after its own particular fashion the Heat which it receives, and of applying it as a constructive power to the building-up of its fabric after its characteristic type.

THE REPUTED FOSSIL MAN OF THE NEANDERTHAL.

By Professor William King, Queen's University in Ireland, and Queen's College, Galway.

As it is my intention to confine myself to the consideration of the Neanderthal fossil with reference to its place in Nature, I must necessarily be brief in my remarks on the circumstances under which it occurred, and on its geological age.

The fossil was found in 1857, embedded in mud in a cave or fissure intersecting the southern rocky side of the ravine or deep narrow valley, called the Neanderthal, situated near Hochdal between Düsseldorf and Elberfeld. A small stream or rivulet, known as the Düssel, flows along a narrow channel about sixty feet below the lowest part of the fissure, and on one side of the valley.

It has long been known that human bones, belonging to an extinct race, and occurring in stalagmite along with the remains of the mammoth and other fossil animals, have been found in the limestone fissures or caverns of the lofty precipices which overhang the river Meuse, in Belgium, about seventy English miles south-west of the Neanderthal.

Lyell's late work, 'The Antiquity of Man,' contains a very lucid description of the Meuse caverns, and of the one under consideration. In both cases it is evident that we have examples of ancient swallow-holes, into which have been washed bones, mud, and gravel, when their openings existed in the bed of large and powerful rivers. It was doubtless by the incessant abrading action of such ancient streams, continued for countless ages, that the Neanderthal, and much of the broad valley of the Meuse, became scooped out.

Few Geologists will dispute that the Meuse caverns are of the same age as the flint-implement gravels of the Somme, and that both belong to the latest division of the glacial or (as I have lately termed it) Clydian period.* If we accept the physical conditions of the Meuse caverns as demonstrative of their having been filled up in that remote age, we cannot but recognize in the corresponding conditions of the Neanderthal fissure evidences which claim for it an equally high antiquity, notwithstanding certain differences seemingly supporting the opposite conclusion.

The want of stalagmite and the *doubtful* absence of remains of extinct animals in the Neanderthal fissure may be readily explained; and as to the physical differences, the Düssel is certainly not to be compared with the Meuse for size and abrading power, but it must be admitted that a mere rivulet may take quite as much time to scoop out a "ravine" as a river to excavate a considerable portion of a broad valley.

Having finished my preliminary remarks, I shall next proceed to notice the fossil itself.

According to Dr. Fuhlrott, of Elberfeld, the skeleton was found

* See 'Synoptical Table of the Aqueous Rock-Systems,' 5th edition.

by some workmen while quarrying the rock where the cave occurs; but, knowing nothing of the importance of the discovery, and being very careless about it, they secured chiefly only the larger bones. Fortunately these fell into the hands of Fuhlrott, and they were shortly afterwards described by Professor Schaaffhausen, of Bonn. The principal parts of the skeleton which have been preserved are the cranium; both thigh bones, perfect; a perfect right humerus; a perfect radius; the upper third of a right ulna corresponding to the humerus and radius; a left humerus, of which the upper third is wanting; a left ulna; a left ilium, almost perfect; a fragment of the right scapula; the anterior extremities of a rib of the right side; the same part of a rib of the left side; the hinder part of a rib of the right side; and two short hinder portions, and one middle portion of some other ribs.

The skeleton, or rather, as much as is preserved of it, is characterized by unusual thickness, and a great development of all the elevations and depressions for the attachment of the muscles. The ribs, which have a singularly rounded shape, and an abrupt curvature, more closely resemble the corresponding bones of a carnivorous animal, than those of man.*

Although a difficulty may be felt in resting a satisfactory argument upon merely the great size of its osseous framework, and the peculiar form of its ribs, it cannot but be admitted that these characters afforded some grounds for the belief, at first entertained, that the Neanderthal fossil had not belonged to a human being. Whether a more close examination of other parts of the fossil will confirm this hypothesis, it is the object of the present paper to determine.

The skull is deficient in its basal and facial portions, but retains all the parts lying above a line connecting the *glabella*—or space between the eye-brows—and the *centre* of the posterior part of the skull immediately above the hollow of the neck, to which the name occipital or posterior tubercle is given.† Fortunately the parts alluded to, which are of uncommon thickness, enable one to determine some highly important points in craniology.

The *frontal*—or bone of the forehead‡—possesses the upper border and roof-plate of the eye-sockets, the inter-orbital space, the orifices of the frontal sinuses, and both outer orbital processes: the upper part of the alisphenoid belonging to the right side appears also to be present. The *occipital*—or posterior bone—retains, in addition to the tubercle, the superior transverse ridges. The *parietals*—or upper side-bones—possess the impression of the temporal squamosal. The *temporals*—or lower side-bones—are broken off, though it would appear from Huxley's figure,§ that the mammillary portion of the left one is still preserved. The *lambdoidal suture*—or joining of the parietals

* See Busk's translation of Schaaffhausen's paper in the 'Natural History Review,' 1861, pp. 158–162.

† The line A A, in Fig. 1, Plate I., passes from the *glabella* to the occipital tubercle.

‡ The explanation of the individual parts of the skull is prefixed to Plates I. and II.

§ See 'Man's Place in Nature,' Fig. 25 A, facing page 138.

and the occipital—including the *additamentum*, is well marked; the *sagittal suture*—or joining of the parietals in the medio-longitudinal line of the skull—is obscure; while the *coronal suture*—or joining of the frontal and parietals in front of, and at right angles to the last-named *suture*—is but faintly marked at the crown and obliterated at the sides. The bounding line of the temporal muscles (situated on each side of the skull in front of, and above the ear) is tolerably well defined.

In general terms, the Neanderthal skull is of an elongated oval form, with a basal outline bearing much resemblance to that of the Negro cranium represented by Martin.* It is of large size, being about an inch longer than ordinary British skulls; in width, however, it does not much exceed them. The forehead, uncommonly low and retreating, terminates in front by enormously projecting brow or superciliary ridges, which, besides being very thick, slightly rounded on their anterior aspect, and rather strongly arched above the eye-sockets, extend uninterruptedly across from one side to the other. The outer orbital processes—or horns of the brow-ridges—are also unduly developed; being thick and projecting. On the whole, there is a remarkable absence of those contours and proportions which prevail in the forehead of our species; and few can refuse to admit that the deficiency more closely approximates the Neanderthal fossil to the anthropoid apes than to *Homo sapiens*.

The greatest width of the skull is towards its posterior part, and on a level not much higher than the mammillary region—a character which is essentially pithecoid or simial. In human skulls, the greatest width is considerably higher—usually on a line connecting the centres of ossification of the parietals:† on the contrary, the Neanderthal cranium, like that of the Chimpanzee, is without any particular prominency where those centres may be assumed to be situated.

In addition to possessing a low retreating forehead, the fossil skull is remarkably flattened at the vertex, which, according to Huxley, rises about 3·4 inches only above what is called the glabello-occipital plane:‡ in Man, the corresponding part is generally about an inch higher. From the vertex there is a slightly curving fall both towards the front and the back, ending in the former direction at the origin of the brow-ridges, and in the latter, at the occipital tubercle. The curving is more rounded and regular on the anterior half—particularly at the upper portion of the brow, which, in consequence, is somewhat prominent—than on the posterior half: on the latter, there is a slight depression just above the apex of the lambdoidal suture. The posterior fall of the Neanderthal skull, as a peculiarity, was first pointed out by Huxley, who remarks that "the occipital region slopes obliquely upward and forward, so that the lambdoidal suture is situated well upon the upper surface of the cranium:" in other words, when the glabello-occipital plane is made horizontal, the apex of the lambdoidal suture is decidedly in front of the posterior tubercle. In ordinary

* 'Natural History of Man and Monkeys,' Fig. 182, p. 120.
† Plate II. Fig. 5, *b*.
‡ See Plate I. Fig. 1, A A.

skulls, it is well known, the backward slope terminates near the apex of the lambdoidal suture, below which the occipital bone stands more or less vertical to the glabello-occipital plane. The Neanderthal cranium, in its posterior features, is approached by some savage races; also occasionally by a few inhabitants of the British Isles. Moreover, judging from the few data at our command, the approximation apparently characterized the ancient "Borreby people," and the extinct race of the Meuse, supposing the latter to be represented by a nearly perfect skull which Schmerling obtained from the Engis cave near Liège;* but in no human tribe extinct, or existing, do we find both the vertex and the occiput so depressed and ape-like. Well might Huxley have felt a "difficulty in believing that a human brain could have its posterior lobes so flattened and diminished as must have been the case in the Neanderthal man."

Much of the hinder half of the skull partakes of the slight roundness just noticed; but anterior to its greatest width, in the areas which were embraced by the temporal muscles, the sides are perpendicular, and their "fore and aft" outline is straight and remarkably long.

In these general characters, the Neanderthal skull is at once observed to be singularly different from all others which admittedly belong to the human species; and they undoubtedly invest it with a close resemblance to that of the young Chimpanzee, represented by Busk in his translation of Shaaffhausen's memoir.†

Another differential feature characterizes the fossil in question. In human skulls, even those belonging to the most degraded races, if the forehead be intersected at right angles to the glabello-occipital plane, on a line connecting the two outer orbital processes at their infero-anterior point, the intersection will cut off the frontal bone in its entire width, and to a considerable extent rising towards the coronal suture; ‡ whereas in the Neanderthal skull, the same intersection will cut off only the inferior and little more than the median portion of the frontal.§ This is quite a simial characteristic, and rarely, if ever, occurs in man.||

* This is the only speciality in which the Engis and Neanderthal skulls agree.

† See 'Natural History Review,' 1861, Plate IV. Fig. 6.

‡ See Plate II. Fig. 5, B B. § See Plate I. Fig. 1, B B.

|| I have examined and made myself acquainted with skulls belonging to the principal races or varieties of man, in all of which the forward position of the forehead, relatively to the outer orbital processes, is the general rule. The Engis skull exhibits it, and the same appears to be the case with the Borreby one, judging from the figure in Lyell's 'Geological Antiquity of Man,' p. 86. It may be doubted that the Plymouth skull, represented by Busk ('Nat. Hist. Rev.' 1861, Pl. V. fig. 6), is an exception. I possess a very remarkable skull, probably about 500 years or more old, taken last summer out of the beautiful ruins of Corcomroo Abbey, situated among the Burren mountains, in county Clare, which offers a close approximation to the fossil in the depressed form of the forehead: indeed, although not altogether so abnormal in this respect as the Neanderthal skull, it has in appearance a better development, in consequence of the median part of its frontal being a little more rounded. There is no reason to believe that it belonged to an idiot, as it happens that most of the skulls lying about the ruins have a low frontal region. It is singular that the inhabitants of Burren a few hundred years ago should have been characterized by a remarkably depressed forehead, while those now living have a well-developed cranial physiognomy.

The last peculiarity is concomitant with another equally striking. Viewing the Neanderthal forehead with reference to the situation of that portion of the brain which it enclosed, we may plainly perceive that the frontal lobes of the cerebrum have been situated *behind* the outer orbital processes. As far as I have ascertained, we cannot say this of man; for, apparently, in all existing races, whose skull has not been modified by artificial pressure, the corresponding parts of the brain actually extend in *front* of the orbital processes.*

Notwithstanding the strong simial tendencies displayed by its general features, most of the writers who have described this skull do not appear to think otherwise than that it belonged to an individual of our species. There seems to be no doubt, whatever, on the part of the Honorary Secretary of the Anthropological Society, Mr. Carter Blake, that the Neanderthal fossil is specifically *identical* with Man. He considers it to be the remains of some poor idiot or hermit, who died in the cave where the bones were found.† His reasons, however, are obviously unsatisfactory. "In reply to the suggestion," observes Huxley, "that the skull is that of an idiot, it may be urged that the *onus probandi* lies with those who adopt the hypothesis. Idiotcy is compatible with very various forms and capacities of the cranium, but I know of none which present the least resemblance to the Neanderthal skull."‡ Blake admits that its frontal peculiarities give the cranium an "apparent ape-like character;" but if such peculiarities be the result of mal-development producing idiotcy, one would be equally justified in believing that the form of the skull of the gorilla, or chimpanzee, is also produced by disease of the brain. Schaaffhausen, seemingly, would have no hesitation in repudiating the idea that the frontal specialities of the fossil are the result of individual pathological deformity.§

In case it should be suggested that this remarkable cranium has received its form from artificial pressure, I may observe that no one who has described it seems to entertain such an opinion; indeed its symmetry, also noticed by Schaaffhausen, is quite opposed to the supposition that the skull has undergone any process of artificial modification.

Huxley, while admitting that it is the most ape-like and most brutal of all human skulls yet discovered, states that it is "closely approached" by some Australian forms, and "even more closely affined to the skulls of certain ancient people, who inhabited Denmark during the Stone period."‖ I have no intention to deny that there are gene-

* The Corcomroo skull, noticed in the previous footnote, although closely approximated to the Neanderthal one in its low forehead, and *this alone*, is strictly human in the forward extension of the frontal lobes of the brain relatively to the outer orbital processes.

† See 'Geologist,' vol. V. p. 207.

‡ See Lyell's 'Geological Antiquity of Man,' p. 85.

§ The writer of an article on Lyell's 'Geological Antiquity of Man,' in the last number of the 'Quarterly Review,' summarily disposes of the Neanderthal skull with the gratuitous assertion, that it is quite removed from the pithecoid type, and possibly belonged to an idiot.

‖ 'Man's Place in Nature,' p. 157.

ral features of resemblance between the Australian, Neanderthal, and ancient Danish crania; but it appears to me, judging from the figures (31 and 32) in the deeply philosophical work, 'Man's Place in Nature,' that a closer resemblance is assumed than really exists. No one would have any hesitation in admitting that the Borreby skull, represented under one of the figures cited, is strictly human,—nay, from what I have seen myself, I have no hesitation in saying that precisely the same cranial conformation is often repeated in the present day; but it has yet to be shown that any skulls hitherto found are more than *approximately* similar to the one under consideration.

The proposition at present contended for is apparently invalidated by the fact that, among certain species of animals—notably those under domestication—skulls very dissimilar from each other may be found. It is, therefore, to be apprehended that, however clearly the Neanderthal fossil may be shown to be inadmissible into the human species, an attempt will be made to set aside the consequent conclusion by an appeal to the fact alluded to. But this I contend is not a case in point, as will be evident after a moment's reflection on the various breeds of the Dog—the best known of our domesticated species. These breeds, so remarkably differentiated by cranial peculiarities, are *artificial*, whereas the varieties of mankind are *natural*. The dissimilar skulls met with in the former are merely striking illustrations of organic or structural modifiability, produced by what Darwin calls Natural Selection, but nothing more.

Again, some weight seems to be due to the consideration that the human species (in which I include all the existing races of man) is characterized by a great variety of skulls. We have abundant examples affording characters which closely link together the most dissimilar forms, so that it is impossible to draw a line of demarcation between the extremes of dolichocephaly and brachycephaly,* or between the lofty forehead of Indo-Europeans and the depressed one of the Australian. Nay, the most degraded race we are acquainted with—the Mincopies of the Andaman Islands—may be strictly regarded as closely affined by cranial conformation to the highest intellectual races. It might, therefore, be urged that the Neanderthal skull is simply an aberrant form, but which is, nevertheless, inseparably linked on to the Indo-European type. If sufficient has not yet been adduced to dispel this idea, the following additional evidences, referring to the particular parts of the bones composing the fossil cranium, will, it is thought, be deemed fully adequate for the purpose.

Commencing with the *Frontal.*—Fuhlrott and Huxley have satisfactorily shown that this bone is furnished with large frontal sinuses; and apparently they regard these as the cause of the excessive prominency of the superciliary ridges. It may be reasonably doubted, however, that this is the case. Frontal sinuses, it is well known, do not always coexist with prominent brow-ridges, as, for example, in the Australian and the Chimpanzee: on the other hand, the former may exist without being associated with any more than an ordinary de-

* Professor Retzius distinguished *long* skulls, and *short* or round skulls, respectively by the names *dolichocephalic* and *brachycephalic*.

velopment of the latter. I have seen frontal sinuses extending to nearly the origin of the outer orbital processes, and almost large enough, even at their termination, to admit the small finger to be inserted into them, yet the brow-ridges were not particularly prominent. But whether the Neanderthal sinuses extend the whole length of the brow-ridges, or they are simply confined to the region of the *glabella*, their large size, in either case, is unusual in man, and they more strongly approach to, or resemble, as the case may be, those of the Gorilla.

As to the excessive prominency of the brow-ridges,—instead of regarding this feature as having been produced by the frontal sinuses,—there is more probability that, like the other extraordinary "elevations and depressions" of the skeleton, pointed out by Schaaffhausen, it is another speciality consequent on the greatly developed muscular system, which, from what has already been stated, evidently characterized the so-called Neanderthal man.

The orbital cavities appear to have had a circular rim, as in certain apes, there being no angle in that part joining the glabella. This is a feature unknown in any of the human races: in them the orbits are always subquadrate.*

The roof of the orbital cavities is altogether less concave, particularly on the outer side, than in Man; and, although the inner extremity of the plate forming the roof is broken off, sufficient remains to show that the cavities contracted sooner than usual. The cavities also *appear* to have been uncommonly divergent: if this were actually the case, its significance would point towards one of the specialities of the Gorilla.

Temporals.—As already stated, only the impression of the upper *squamosal* is seen on the parietals; but it suffices to show, as pointed out by Huxley, that this part had a comparatively low arcuation: the highest point of the arch reaches little more than half the height it attains in ordinary human skulls. Besides occurring among apes, an equally low arcuated squamosal distinguishes the human fœtus; and in some savage races—Australians and Africans—the same part is also depressed, but not so much as in the fossil. The Engis and Borreby skulls are strictly normal in this particular.†

* In some apes the rim of the orbits is of the human form.

† Under this head may be noticed a part which appears to have been overlooked in the fossil. On an excellent cast, supplied by Mr. Gregory, of Golden-square, London, there occurs on the right side and in front of the squamosal impression a raised flattened plate, which looks like the upper portion of the alisphenoid (see Plate I. Fig. 1, *b*): the forward situation of this plate prevents it being taken for the anterior part of the temporal; besides, its posterior side exhibits what appears to be the impression of the squamosal. The anterior margin of the supposed alisphenoid is about an inch behind the outer orbital process. Dr. Knox long ago pointed out in a Tasmanian skull a square-shaped bone, nearly an inch in extent, interposed between the alisphenoid and the parietal. I perceive that this abnormality in a Tasmanian skull is represented in Fig. 225 of the beautiful edition, just published by Renshaw, of Dr. Knox's translation of Milne-Edwards' 'Manuel de Zoologie.' I have also seen the same bone, but only on the left side, of an "Australian" skull belonging to the Dublin University Museum. Perhaps this interposed bone corresponds, in nature as well as situation, to the flattened plate observable in the Neanderthal fossil.

Occipital.—The upper portion of this bone is quite semicircular in outline, its sutural (lambdoidal) border running with an even crescentic curve from one transverse ridge to the other:* generally in human skulls, including the Engis one, the outline approaches more or less to an isosceles triangle.† The width of the occipital at the transverse ridges is much less than is common to Man; and the disparity is the more striking in consequence of the widest portion of the fossil occupying an unusually backward position.

Taking into consideration the forward and upward curving of the upper portion of the occipital bone as previously noticed, its semicircular outline, and smallness of width, we have in these characters, taken together, a totality as yet unobserved in any human skull belonging to either extinct, or existing races; while it exists as a conspicuous feature in the skull of the Chimpanzee.

Parietals.—In Man the upper border of these bones is longer than the inferior one; but it is quite the reverse in the Neanderthal skull. The difference, amounting to nearly an inch, will be readily seen by referring to Figures 1 and 2, in Plate II.; the former representing the right parietal of a British human skull, and the latter the corresponding bone of the fossil. These figures also show that the Neanderthal parietals are strongly distinguished by their shape, and the form of their margins: in shape they are five-sided, and not subquadrate, like those of the British skull; ‡ while their anterior and posterior margins have each exactly the reverse of the form characteristic of Man.

The *additamentum,* which undoubtedly gives the parietals their five-sided shape, is on a level with the superior transverse ridge, and much longer than usual. This peculiarity is common to the human fœtus: I have, likewise, observed an approach to it in a "Caffre" skull belonging to the Dublin University Museum, in which, also, the upper and lower borders of the parietals are about equal in length. But still the abnormality of the latter case is not at all so extreme as the condition observed in the fossil. These particular features also are characteristically simial; for in extending our survey to the Chimpanzee, and some other so-called Quadrumanes, their parietals are seen to present a great similarity to those of the Neanderthal skull.§

I have now, as it appears to me, satisfactorily shown that not only in its general, but equally so in its particular characters, has the fossil

* Plate II. Fig. 4. † Plate II. Fig. 3.

‡ The outlines were taken by pressing a sheet of paper on the parietals; and, when in this position, marking their margins by following the bounding sutures; next, by cutting the paper according to the lines given by the sutures, and allowing it to retain its acquired convexity: the outlines were then marked off on another sheet of paper. Possibly the antero-inferior angle of the Neanderthal parietal, as given in the figure, is not strictly correct, owing to the coronal suture being obliterated in that part, but I venture to state that it is approximately true.

§ On the cast, an incised line runs from the lambdoidal suture (where the *additamentum* joins it) towards the posterior tubercle. Is this the suture which occurs near and parallel to the transverse ridges in fœtal skulls, and occasionally in that of adults? In the skull of the "Caffre," noticed in the text, this suture, which is only seen on the right side, is situated above the ridge; but in the fossil, it is below this part.

under consideration the closest affinity to the apes. Only a few points of proximate resemblance have been made out between it and the human skull; and these are strictly peculiar to the latter in the *fœtal state.* The cranium of the human fœtus, however, possesses the lofty dome, the forward position of the frontal respectively to the outer orbital processes, the greatest width at the parietal centres of ossification, and the vertical occipital, which are so conspicuous in the adult, but which are remarkably non-characteristic of the Neanderthal skull. Besides, so closely does the fossil cranium resemble that of the Chimpanzee, as to lead one to doubt the propriety of *generically* placing it with Man. To advocate this view, however, in the absence of the facial and basal bones, would be clearly overstepping the limits of inductive reasoning.

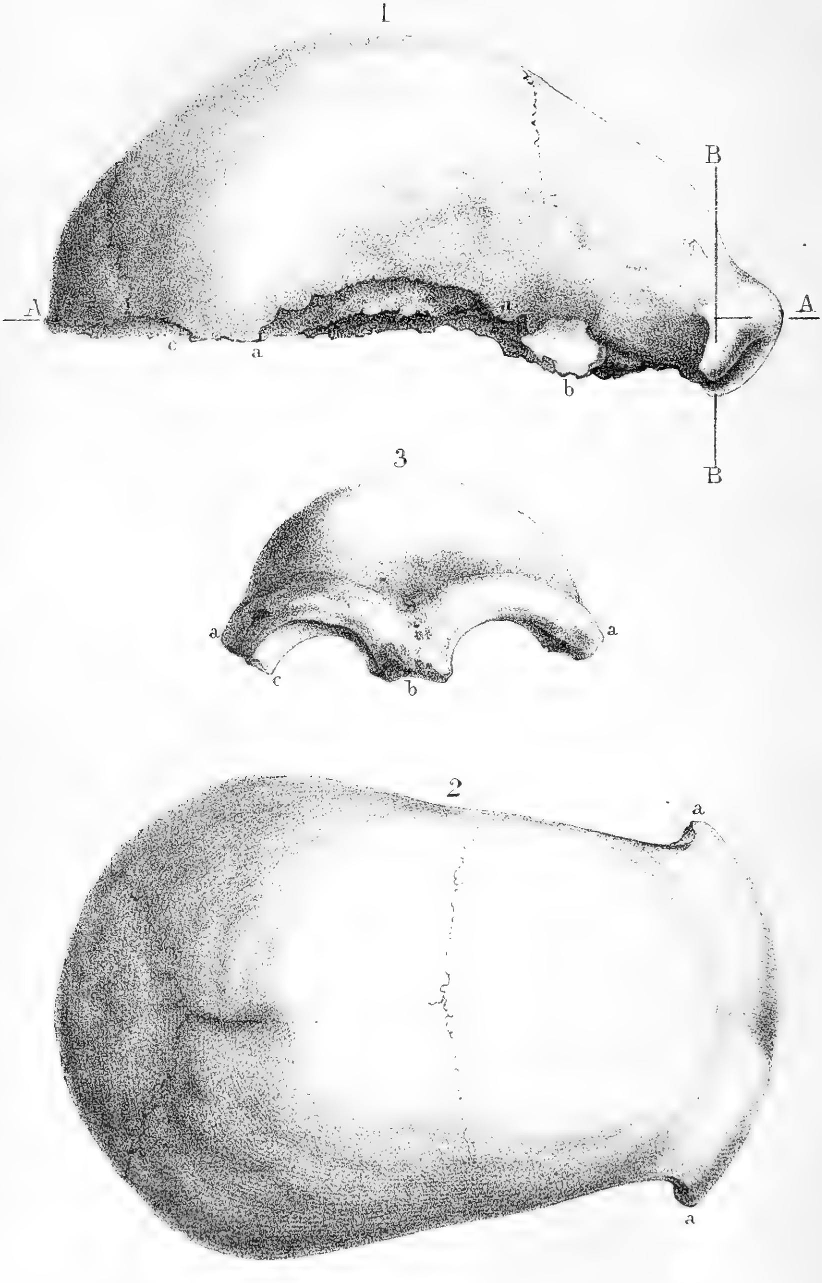
Moreover, there are considerations of another kind which powerfully tend to induce the belief that a wider gap than a mere generic one separates the human species from the Neanderthal fossil.

The distinctive faculties of Man are visibly expressed in his elevated cranial dome—a feature which, though much debased in certain savage races, essentially characterizes the human species. But, considering that the Neanderthal skull is eminently simial, both in its general and particular characters, I feel myself constrained to believe that the thoughts and desires which once dwelt within it never soared beyond those of the brute. The Andamaner, it is indisputable, possesses but the dimmest conceptions of the existence of the Creator of the Universe: his ideas on this subject, and on his own moral obligations, place him very little above animals of marked sagacity; * nevertheless, viewed in connection with the strictly human conformation of his cranium, they are such as to specifically identify him with *Homo sapiens.* Psychical endowments of a lower grade than those characterizing the Andamaner cannot be conceived to exist: they stand next to brute benightedness.

Applying the above argument to the Neanderthal skull, and considering that it presents only an approximate resemblance to the cranium of man, that it more closely conforms to the brain-case of the Chimpanzee, and, moreover, assuming, as we must, that the simial faculties are unimprovable—incapable of moral and theositic conceptions—there seems no reason to believe otherwise than that similar darkness characterized the being to which the fossil belonged.†

* It has often been stated that neither the Andamaners, nor the Australians, have any idea of the existence of God: there are circumstances, however, recorded of these races which prevent my accepting the statement as an absolute truth.

† A paper advocating the views contained in this article was read at the last meeting of the British Association, held in Newcastle-on-Tyne. In that paper I called the fossil by the name of *Homo Neanderthalensis;* but I now feel strongly inclined to believe that it is not only specifically but generically distinct from Man.



Ælian A. King, Del[t] Edwin M. Williams, Sc

REPUTED [illegible] OF NEANDERTHAL, [illegible]

EXPLANATION OF PLATE I.

FIG. 1.—*Right Side of Neanderthal Skull.*

A A. Glabello-occipital plane.
B B. Line intersecting the forehead at right angles to the last plane through both outer orbital processes.
(These lines are interrupted so as not to obscure any parts of the skull.)
a to a′. Border of squamosal impression.
(Letter 'a' is just below the widest part of the skull.)
b. ? Alisphenoid.
c. Portion of additamentum.

FIG. 2.—*Top of Neanderthal Skull.*

a, a. Outer orbital processes.
The transverse line on the middle of skull represents the coronal suture. (This and the corresponding line in Fig. 1 are copied from Busk's figures.)
The semicircular line at the posterior part of skull represents the lambdoidal suture.
The medio-longitudinal line represents the sagittal suture.

FIG. 3.—*Front of Neanderthal Skull.*

a, a. Outer orbital processes or horns of the brow-ridges.
b. Inter-orbital space.
c. Portion of roof-plate of right orbital cavity.
(Only the anterior half of the frontal bone is represented.)

*** The figures in this plate are taken from a plaster cast.

EXPLANATION OF PLATE II.

FIG. 1.—*Right Parietal of a Human* (*Irish*) *Skull.*

a. Coronal edge.
b. Lambdoidal edge.
c. Sagittal edge.
d. Squamosal edge.

FIG. 2.—*Right Parietal of Neanderthal Skull.*

a, b, c, d. Same as in last Figure.
e. Additamental edge.

FIG. 3.—*Occipital of a Human* (*Irish*) *Skull.*

a a. Lambdoidal edge.
b, b. Transverse ridges.
c. Occipital or posterior tubercle.

FIG. 4.—*Occipital of Neanderthal Skull.*

Letters same as in last Figure.

FIG. 5.—*Right Side-view of Dome of Human Skull*

A A. Glabello-occipital plane.
B B. Glabello-occipital intersecting plane.
a. Frontal.
b. Parietal. (The letter is on the centre of ossification and widest part of the skull.)
c. Occipital.
d. Temporal.
e. Alisphenoid.

CHRONICLES OF SCIENCE.

I. AGRICULTURE.

The movements in the Agricultural world during the past few months have related more to the business than to the Art of land cultivation. Agricultural Societies and Meetings have concerned themselves more with such questions as the relations of landlord and tenant, or of master and servant, than with details of the processes of the farm, or of the appliances by which they are carried out. And just in proportion as the motive—the efficient cause—is important in comparison with the mere machinery, so the nature of these business relations will, in any occupation or profession, always be the chief of all the influences affecting progress or success.

This is especially the case in Agriculture:—

When the landowner guarantees possession of a farm for a number of years, and does not restrict its cultivation to any precise routine of operations, he induces the tenant of that farm to apply all his mind and all his money to its management, for then there is given to him hope and opportunity of a reward for his outlay and his labour. The land is to a certain extent a machine, and its fertility depends on the use that it can make of the fertilizing influences of air and rain. Its powers as a machine in this respect can, in the case of wet and water-logged soils, be wonderfully increased; but the alterations needed for this purpose are very costly. Land-drainage, marling, liming, burning, are all expensive operations. A man may, in the case of wet clay soils, sometimes profitably spend nearly as much again in these improvements as the land is worth. It is folly to suppose that he will do this on the lands of another. They must be made his own on certain conditions and for sufficient time to enable him to reap the reward of that increased fertility which has been conferred. A lease is thus, for all purposes of considerable land improvement by the farmer, absolutely necessary.

Where, however, the improvements do not involve so large an expenditure, and where that expenditure can, under the several branches of it, be accurately recorded, it becomes possible so to keep an account between the landlord and tenant as to enable the former to repay the latter at any time, whatever may be due from the one to the other. And the system of tenancy at will, coupled with an agreement for the repayment of the balance of this account, does, in many parts of England, both maintain and promote a very high degree of cultivation. Nevertheless, this is but a makeshift arrangement, by which landowners hope to obtain the full advantage to all classes of a large expenditure of tenant's capital without in any degree abandoning those special privileges to themselves which the possession of landed property alone confers. And thus the Earl of Shrewsbury, at one of the recent discussions on the form of an agreement on this principle between landlord and tenant, gave the fullest acquiescence to the principle of repaying the tenant for his outlay; but at the same time the completest refusal to the principle, far more influential for good, of granting leases to his tenants for terms of years. On the one hand, he said:—

"I should feel it to be dishonest if I allowed any tenant of mine to leave me in debt to him. If a man put on to a farm that which would improve it, I should feel bound not to let that man leave my estate without being remunerated for what is unexhausted."

On the other hand, he also said:—

"I adhere to what I have always said respecting leases, namely, that nothing will induce me to give a man a lease, because in the first place a lease is all on one side. The landlord remains, but the tenant, if he be inclined to be fraudulent, may go. I boldly and honestly state that I will never surrender my property to a tenant. I mean that no man who will allow his sons to poach and act disgracefully shall have control over my land for a number of years."

With whatever cordiality we may admire the evident honesty in every sense which these remarks display, it is also evident that they are dictated by an erroneous judgment, not only of the interest of landowners, but of the general character of tenantry.

The lease is not "all on one side." It not only confers advantages on the tenant, but it secures the annual payment of the sum at which those advantages have been valued by the landlord. The landlord does not "remain:" his successor may be either himself in a different mood of mind, or the inheritor of his estate; and in either case it is within his power to put an end to an unwritten bargain.

Again, a landlord does not "surrender his property to a tenant" under the lease, so much as the tenant is asked to surrender his property to the landlord under tenancy at will. Unlike the tenant's share in the improvements he confers upon the land he occupies, the land *remains.* Baron Liebig indeed speaks of the exhaustion of the land, but no such thing is known in practice. The "worn-out" farm of the practical man would be readily taken again by another tenant at the former rent, if only it were let to him for a year or two for nothing. Two years' rent, 3*l.* or 4*l.* per annum, are thus probably the utmost injury ordinary land receives by cross-cropping and hard usage. And if land be let on lease, you must suppose its tenant to be not only fraudulent but a fool, to do even this amount of injury to it. The fear which a landlord expresses lest his property should be injured by letting it out of his hands for so long a time is thus altogether visionary. The tenant's capital is to a great extent the cause of, and it is the security for, its fertility. That system which most encourages the outlay of this capital is best in the interest of the landlord as well as in that of the tenant and consumer.

And the fear of having an ill-conditioned set of neighbours permanently collected round you by granting leases, is equally visionary. It has been proved in other walks of life that the plan of universal restriction—of treating all men with suspicion—of making your general arrangements hinge on the possibility of every man being a rogue, is a blunder. It is an especial mistake in Agriculture. For

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there is a certain class-colouring perceptible in farming, as in other professions, and tenant-farmers may be safely spoken of as a worthy and well-conditioned body of men. If, as is sometimes feared, a general prevalence of the lease should displace the homely and neighbourly class with whom in English country districts one has so long enjoyably associated, by a set of energetic, ruthless, restless, money-making "sharps," the change would be lamentable indeed; but the fear is ludicrous. However many new men may be entering Agriculture from other walks of life, it will always be that the bulk of farmers have been bred by farmers. And it is an easier and a better thing to engraft upon the characteristic good qualities of this class, or rather (for they already exist) to foster in them the intelligence and enterprise, and energy of commercial life, by adopting more generally a commercial view of the relations between landlord and tenant, than it will be to engraft a strict valuation and acknowledgment of tenant right upon the system of tenancy-at-will.

Although this Journal is devoted rather to the consideration of science than of business, yet the case of Agriculture, owing to the peculiarity of its raw material, land, is so exceptional, that these general remarks on what, more than anything else, determines its progress and improvement, may be permitted in a paper introductory to a quarterly series, descriptive of the progress and improvement which from time to time will have to be recorded.

And as a preliminary study of the subject which will thus at intervals engage us, we will now shortly enumerate the particulars in which this progress consists, or to which is owing increased produce of food from the land.

1. It is owing in the first place to better tillage. The object of tillage is the creation of an increased available surface within the soil, on which may be prepared and deposited food for plants, and over which the roots of plants may feed. The greater the quantity of this internal superficies to act as a laboratory, as a warehouse, as a pasturage, and the better stored it is, under a given extent of land, then so long as the fitness of the mechanical condition of the land with reference to particular plants is preserved, the more fertile is that land with reference to those plants.

In order to the creation of this inner surface a greater depth of soil is stirred, and clods are comminuted. In order to the increased accessibility of this inner surface land is drained. The air and rain water which then traverse soil and subsoil instead of merely lodging in them, introduce substances into this warehouse and activity into this laboratory.

The air which rain-water thus draws through the soil as it sinks downwards to the drains is as necessary to the fertility of the soil as it is to the heat of burning coals. The fire will merely smoulder until, by the erection of a chimney over it, a current upwards through the burning mass is impressed upon the air. And even then, in fires of caking coal, the heap may smoulder until, by the smashing of the fuel, that inner surface of the fire, where the action of the air takes place, throughout is multiplied, and the impervious ceiling—or floor, as we might call it, to an upward current—which has hindered the passage of the air over that inner surface, is broken up.

Land drainage is the provision of a passage for the rain-water, along with which the fertilizing air has thus a downward current given it through the soil and subsoil. And tillage, especially tillage by steam-power, which does not cake a floor, as horse-power does, beneath the soil it stirs—has all that enlivening effect of the poker on a caked coal fire, which the parallel suggests. Extended drainage has a great deal to do with our increased produce. Mr. Bailey Denton estimates that nearly 2,000,000 acres have within the past fifteen years been under-drained, and the fertility of these acres has no doubt been largely increased.

Deeper and better tillage has contributed to the same result. The extension of autumnal tillage is an undoubted fact; the enormously increased use of implements of the grubber class is another; the general adoption of a better form of plough is a third; the more general adoption of the fertilizing practice of burning clay soils is a fourth. The success which has at length rewarded unconquerable perseverance in the attempt to use steam-power for tillage operations is a further great fact, which, if it cannot yet be quoted in explanation of agricultural progress, will unquestionably be looked back upon ten years hence as having contributed largely to the increased fertility which will then have to be recorded.

2. In the second place our agricultural progress has been owing to the greater richness of home-made manures, and to the greater use made of imported fertilizers. The imports of guano since 1840 have amounted to 3¼ millions of tons; the imports of cubic nitre, which averaged 10,000 to 14,000 tons per annum up to 1858, have since varied from 25,000 to 40,000 tons per annum. The imports of bones since 1848 have increased from 30,000 to 70,000 or 80,000 tons annually. All these are manuring substances. 75,000 to 80,000 tons of Suffolk and Cambridgeshire coprolites, and 15,000 to 20,000 tons of Sombrero phosphate, are also used in the superphosphate manufacture, which now probably exceeds in worth £1,000,000 per annum. To facts like this add the enormous extension in the use of oil cakes and richer foods in the meat manufacture, by which the richness of home-made manure is increased—the increased adoption of the practice of applying manure at once to the land, instead of rotting it in heaps, which is an economy, and so an addition to our resources worth naming—the increased practice of feeding and collecting manure under shelter, which is another great economy—and the increased care to properly pulverise and even dissolve manures, so as to distribute them thoroughly through the soil, which is another first-class example of a most important improvement in farm practice. On the other hand there is the increased value of the town sewage—due to the improved drainage of our towns—which is still suffered to go to waste. On the whole, however, there cannot be a doubt that the increased fertility of the soil is due not only to improved drainage and tillage, but to the direct application of fertilizing ingredients in a more liberal and economical manner.

3. Leaving now the soil, there is the way in which its increased

fertility is developed and expressed. It will on the whole be admitted that, at least on arable lands, there are fewer weeds; our fallow crops are cleaner, our tillage and manures are not so much wasted on plants we do not want to grow.

Another fact of importance is the prevalence of rotations of crops in which bare fallows are diminished, and in which there is a larger acreage of the more valuable crops. The prevalent rotation of the country is the four-field course, in which wheat, turnips, barley, and clover occupy one-fourth of the land apiece. But it is common on well-cultivated land—where the land is folded by cake-fed sheep, and where a top-dressing of guano is given to the corn, to take a crop of wheat between the turnips and the barley, so that three-fifths instead of two-quarters of the land are in grain crops. One-half of the clover land, too, is often sown instead with peas or beans, so that five-eighths instead of three-fifths are in grain. Again, over large districts, especially in Scotland, potato culture to a great extent displaces turnips or other fallow crops, and thus provides a great increase of food for man.

But besides the adoption of improved rotations, we have to report the improved cultivation of individual crops. We suppose that the gradually diminished quantity of seed used per acre in growing grain crops—as drill husbandry extends, and as an increased independence of mere custom becomes the rule, each man determining his practice for himself—will be admitted by most people as an example of this kind. Certainly every one will admit that the extension of drill husbandry in the cultivation of root crops, the extended use of the horse-hoe in the cultivation of grain crops—the extended use of so-called artificial manures as top-dressings and otherwise in the cultivation of all crops—all illustrate the improved cultivation of the plants by which the greater fertility of our soils is expressed and utilized.

Again, we owe our better crops to the selection and adoption of better sorts of the plants in cultivation. We do not suppose that individual sorts have improved upon our hands. Probably, as a general rule, they have deteriorated. But new sorts are being perpetually introduced; and of wheat, barley, and oats, mangold-wurzel, swedes, turnips and potatoes, cabbages and vetches, a man can grow sorts as good as any—we think probably better than any—that his predecessors have known.

4. We now come to the produce of meat, and the question of sort has a great deal to do with our improvement here. Our sheep are now ready for the butcher at 14 months old; our cattle at 24 and 30 months. Formerly it needed at least two years of feeding to make a smaller carcase of mutton, and at least three or four years' feeding to make a smaller carcase of beef. A thousand sheep upon a farm in March or April now mean something like 500 ewes in the lambing fold, and 500 sheep ready for the market. Formerly they meant not more than 300, and those a smaller lot ready for the butcher. And this great increase in the meat produce of a given head of stock is witnessed as much in pork and beef as it is in mutton.

All the important breeds of cattle, sheep, and pigs have improved and increased in numbers during this period. Mr. Strafford receives entries for his herd book from fourfold the number of short-horn breeders; and the influence of this, the dominant breed of cattle, in crossing the general stock of the country, has wonderfully increased. Messrs. Duckham and Tanner Davy report no falling off in the number and quality of the more local breeds of Hereford and Devon. Both Down and long-woolled sheep, and especially the latter, have made great strides, both as to increase of numbers and general improvement; and much more general interest is taken in the improvement of the breeds of swine. The public attention has lately been drawn, or rather driven, to the fact that disease is rife among our stock, and it is said to be increasing. It is one great point in proof of great agricultural improvement that an evil of this kind, whether general or local, and wherever it exists, is not now left to fester, but is exposed and probed by an energetic public agitation, which will undoubtedly promote its cure.

The greater rapidity of growth, and the increased size of our improved stock, are owing partly to the better food we give our stock, as well as to their increased precocity, and the enormous extension of better bred stock. And thus, as part of this experience, we have a supply of more fertilizing manure and an increased growth of grain crops. It is, we believe, the fact that there are more acres of corn grown now than before has been ever known in England, and we look upon this as a proof of agricultural progress. And, so long as this is consistent with the maintenance of fertility, it is certainly for the interests of the consumer. It is said our climate is especially favourable for the growth of green crops. We believe there are more bushels of wheat per acre grown here than in any other country, whether we have so good a climate for it or not. And if the present extravagant cry for laying land down to grass which has hitherto grown grain and green crops in alternate husbandry shall to any extent prevail, we do not know who is to benefit by the change. Landlord, tenant, labourer, and consumer are alike interested in the larger produce and more energetic cultivation of arable land.

The progress which we have thus sketched has been achieved rather by the extension of good Agriculture than by the invention of any new process during the period of it; and yet there is enough of novelty and change apparent, too, on comparing the present farmer with his predecessor. Bones and rape-cake, soot and salt and gypsum, lime and marl, and composts used to be the principal methods of adding directly to fertility; and indirectly the same end was attained by the cultivation of successive green crops, feeding rye and rape, vetches and turnips, and cabbages off successively upon the same field. This "double" culture was advocated confidently as the perfection of arable cultivation twenty-eight or thirty years ago. Hear Mr. Middleton, who edited the 20th edition of Arthur Young's 'Farmer's Calendar,' writing on this very practice. "That very numerous class of supine persons," he says, "whose minds are so weak as not to adopt this practice, which is the most improved that is known, will certainly continue to complain of hard landlords and bad times. Such characters do not succeed in any profession; neither can they in Agriculture. I had nearly said they deserve to be poor, but, whether they deserve it or not, their destiny is to be so."

Notwithstanding, however, Mr. Middleton's vigorous assertion of this practice, it is not thus that the farmer now in general seeks the increased fertility of his lands. He has guano, superphosphate, and other fertilizers at his command. He has machinery, not only for the increased efficiency, but for the cheapening of all agricultural processes. Steam-power both tills the soil and threshes out its produce. The mowing machine, hay-tedder, and reaper—the chaffcutter, pulper, and steamer—cheapen the labour of securing his crops, and economize the after-use of them. Better plants are grown, and better animals are fed, and the fertility which formerly came with profit under the best management in two or three years, is now achieved, with at least an equal profit, almost at once.

It will thus be seen that there is a large field over which the reader of the agricultural section of this Journal may expatiate. And in the improvements of machinery and soil, of manures, and plants and animals, there is scope enough both for the ingenuity and energy of the practical and scientific man, and in the present activity of both in the agricultural world, for the industry of the recording Journalist.

II. ASTRONOMY.

Germany, ever foremost in practical astronomy has, within the last few months, seen the inauguration of a movement likely, if well carried on, to render valuable services to the science. The celebrated band whose organization in the early years of the present century resulted in the discovery of the planetoids, Pallas, Juno, and Vesta, may be said to have paved the way for the new institution we have now to report upon, and there is no reason to doubt that the results in the present case will be equally, if not still more satisfactory. "The Astronomical Society of Germany," modelled in some respects on our own, is distinguished therefrom by including in its programme a scheme for united work which appears very promising. It is well known that there are certain classes of research demanding for their proper development more time and attention than a single observatory, much less a single observer, can possibly be expected to afford—variable stars and comet sweeping are two noticeable examples. By a well-adjusted subdivision of labour amongst several persons, each undertaking a prescribed department or area of the heavens, as the case may be, it is obvious that results of extreme magnitude and importance may be arrived at. A copy of the prospectus has been forwarded to us from Germany: from it we learn that Leipzic will be the general head-quarters, and that German will be the official language for the transaction of business, though the Society will be open to all nationalities and all languages. Both the entrance fee and annual subscription are fixed at five thalers (15*s.*), a very moderate sum by the side of the three guineas and two guineas which our own Society charges for very inadequate returns. Amongst the officers elected at the Heidelberg foundation meeting, are Zech of Tübingen (President), Argelander, O. Struve, Bruhns, Schönfeld, &c. The secretary is Förster, of the Royal Observatory, Berlin, well known as an expert calculator.

In reviewing the progress of Astronomy during the last six months, we shall scarcely do wrong in assigning a foremost place to some remarks on the belief which has recently taken hold upon the minds of leading men, that it is now necessary to adopt some revised estimate of the sun's distance from the earth. The precise amount of the reduction to be made in the hitherto-received value is open to future determination, but concerning the general fact that some correction is requisite there seems to be no difference of opinion. The first really public announcement at any considerable length is due to Mr. Hind, who contributed a very lucid memoir on the subject to 'The Times' in the month of September last. For our present purpose no more is requisite than to give a brief recapitulation of the matter in Mr. Hind's own words, followed by a few general remarks on two of his heads which appear to deserve comment. He thus sums up:—"A diminution in the measure of the sun's distance now adopted is implied by—1st, the theory of the moon as regards the parallactic equation, agreeably to the researches of Professor Hansen and the Astronomer Royal; 2nd, the lunar equation in the theory of the earth, newly investigated by M. Le Verrier; 3rd, the excess in the motion of the node of the orbit of Venus beyond what can be due to the received value of the planetary masses; 4th, the similar excess in the motion of the perihelion of Mars, also detected within the past few years by the same mathematician; 5th, the experiments of M. Foucault on the velocity of light; and 6th, the results of observations of Mars when near the earth about the opposition of 1862."

To Encke we owe the best discussion of the observations of the transit of Venus in 1769: he determined the value of the sun's parallax to be 8″·5776, from which we infer the earth's mean distance from the sun to be 95,283,115 miles. Now, the time occupied by a ray of light reaching the earth from the sun is known very exactly to be 8m. 18s., from which a velocity of about 192,000 miles per second is deducible. Foucault of Paris, however, by the optical contrivance of a "turning mirror," due to Professor Wheatstone, has concluded that this value is too great; that it is more precisely 185,170 (English) miles. Assuming that Foucault is right, and all his predecessors wrong, it follows that the solar parallax must be 8″·86. Two most singular coincidences must here be disposed of. (1) The *theoretical* value assigned by Le Verrier, irrespective of all instrumental measurements, and purely on physical grounds, is 8″·95; and (2) The discussion, by Stone of Greenwich, of the observations of Mars (adverted to above in Mr. Hind's 6th point), taken by Ellery at Williamstown, Victoria, N. S. W., give a value of 8″·93, with a probable error of only 0″·03. Combining the foregoing, we find that three different observers, working in three most diverse ways, have all arrived at the same general result, and more than this, at actual evaluations, the extremes of which differ only by the minute amount of 0″·09. Is it possible for us to withstand the conclusion that our estimations so long adhered to must sooner or later be materially "reconstructed," and as a consequence, that those portions of our treatises involving this distance must be unceremoniously pulled to pieces and built up again. An original calculation of the mean distance of the earth from the sun, amended according to Stone and Ellery's value of the parallax, makes it 91,512,649 miles.*

Chiefly in consequence of the larger major planets being, during the past autumn, unfavourably placed for observation, we have little to report in the department of planetary astronomy; the inferior conjunction of Venus on Sept. 28, is the only phenomenon of importance which has happened, and none of the observations which have as yet come under our notice contain any features calling for special remark.

The already very long list of minor planets has received one addition due to the labours of Mr. Watson, director, in succession to Brunnow, of the Observatory of Ann Arbor, Michigan, F.S.A. This planet, which takes the ordinal number of 79, was found on Sept. 14, shining as a star of the tenth magnitude. The following provisional elements have been determined by M. Allé, of Prague.†

Epoch 1863, Oct. 4·0, Berlin M. T.

		°	′	″	
Mean Longitude	=	23	0	54·50	
Longitude of Perihelion . .	=	44	56	24·24	Mean Eq. 1863
Ascending Node	=	206	30	58·27	Mean Eq. 1863
Inclination of Orbit . . .	=	4	42	39·20	
ϕ	=	11	13	9·8	wherefore Eccentricity = 0·194563
Log. Mean Distance . . .	=	0·3910464			
Mean Daily Motion . . .	=	919″·2568			

The new planet revolves round the sun in an orbit slightly larger than Parthenope's. It has not yet received a name.

On Nov. 13, M. Schmidt of Athens discovered another, the 80th, in the constellation Taurus. It shone then as a star of the tenth magnitude, but fell rapidly more than a whole magnitude in less than a week from that time.

On October 9 a watchmaker at Leipzic, surnamed Bäcker, had the good fortune to discover a small telescope comet, which Tempel of Marseilles found independently five days later.

The following elements are by M. Romberg:—

Perihelion Passage . . . . = 1863, Dec. 27·70863 G. M. T.

		°	′	″	
Longitude of Perihelion . .	=	180	17	53·4	Apparent Eq. Oct. 14·5
Longitude of Ascending Node.	=	104	51	28·8	Apparent Eq. Oct. 14·5
Inclination of Orbit . . .	=	82	16	29·4	
Perihelion Distance . . .	=	1·3550			
Heliocentric Motion . . .	-	Direct.			

* It should be remarked that parallactic observations of Mars are not generally regarded as susceptible of a high degree of accuracy, and that therefore we shall have to wait for the next transit of Venus (in 1874) to become *well acquainted* with the precise extent of the required diminution of distance.

† 'Astronomische Nachrichten,' November 13, 1863.

These elements bear considerable resemblance to those of Comet ii. 1818. Hereafter it will be reasonable to inquire whether the two bodies are identical, thus adding another 'periodic' comet to our stock of knowledge. It may be added that these elements are not wholly dissimilar to those of Comets i. of 1840 and iii. of 1860; neither should the singular fact be passed over that the three first elements differ but 11°, 12°, and 3° from the corresponding ones of the Comet i. of 1863.

M. Tempel was worthily rewarded, on Nov. 4, for the industry he so untiringly displays, by discovering another comet, one visible to the naked eye, and therefore more than usually interesting.

The following elements are also by M. Romberg:—

Perihelion Passage	=	1863, Nov. 9·49923			
		°	′	″	
Longitude of Perihelion . .	=	94	46	10·6	
Longitude of Ascending Node	=	97	31	15·2	
Inclination of Orbit . . .	=	78	6	46·5	
Perihelion Distance . . .	=	0·70656			
Heliocentric Motion . . .	-	Direct.			

At the time of its discovery this comet was as bright as a star of the 4th magnitude, and it had a short tail. As its perihelion passage preceded that of Bäcker's comet it becomes Comet iv. of 1863, the latter being Comet v., inverting the order of discovery. Both are still visible.

Sidereal astronomy is a branch of the science which, from its very nature, makes progress less rapidly than most others. Labourers are here fewer, because, in many important respects, instruments equal to the work are somewhat scarce. Mr. Lassell, who is diligently engaged in scrutinizing the heavens through the fine atmosphere of Malta, has communicated to the Royal Society an interesting note on the well-known planetary nebula in Aquarius (1 H IV. R. A. 20h. 56m.; δ 11° 56′ S.), in which the following passages occur:—"With comparatively low powers it appears at first sight as a vividly light-blue elliptic nebula, with a slight prolongation of the nebula, or a very faint star at or near the ends of the transverse axis." Under high powers and the most favourable circumstances, "I have discerned within the nebula a brilliant elliptic ring extremely well defined, and apparently having no connection with the surrounding nebula, which indeed has the appearance of a gaseous or gauze-like envelope, scarcely interfering with the sharpness of the ring, and only diminishing somewhat its brightness."

To the same Society, on Nov. 19, Sir John Herschel presented a work, which will, we think, equal any of his former efforts. We allude to a gigantic catalogue of all the known nebulæ, 5,063 in number, compiled from every available source. Sir John's own catalogue of 1833 furnishes 2,307 objects, his Cape observations 1,713 more, the residue being obtained from miscellaneous sources. The epoch chosen is 1860, and the information, arranged in twelve columns, furnishes, amongst other things, constants for reduction and copious synonyms. The catalogue is at present only in manuscript, but we trust that no more time than is absolutely necessary will elapse before this valuable result of Sir John Herschel's indefatigable research is published to the world.

Stellar parallax, in the hands of M. Kruger of Bonn, has yielded results for the stars 21,258 of Lalande's Catalogue, and 17,415 of Oltzen's Zones. To the former he assigns a parallax of $0''\cdot260$, with a probable error of + $0''\cdot02$, and to the latter a parallax of $0''\cdot247$, with a probable error of $0''\cdot021$. From these determinations we must infer that these two stars, both telescopic, are nearer to us than either Capella, Polaris, Arcturus, or Sirius.

Of the various fields of active work open to amateur astronomers, none are so promising as observations on variable stars. The task is a hard one, and requires unquestionably great patience and perseverance, but to those endued with these gifts a fine future is open. The number of known variables is steadily increasing, and now exceeds one hundred, to which the indefatigable Pogson of Madras has added another member within the last few months. He designates it U. Scorpii, and its place for 1860 is R.A. 16h. 14m. 26·6s., δ 17° 33′ 36″ S. It is likely to prove an object of particular interest, having been found by the discoverer to pass through three entire magnitudes in little more than one month, a rapidity of change only known to be equalled by three other stars.

Astronomical photography, in the able hands of Mr. De La Rue and the Kew observers, is making steady progress, but nothing has occurred during the period over which our survey extends, calling for particular notice.

Solar photometry has recently received important development in America under the ingenious manipulation of Mr. Alvan Clarke, the well-known optician. A well of adequate depth not being at his disposal, he made use of a horizontal gallery 230 feet long, through which the sun's rays, on a very clear bright day, were made to pass by the agency of a prism and mirror to obtain the required reflection. He employed a lens $\frac{1}{34}$ of an inch focal length, and thus reduced the sun's diameter 93,840 times, when it presented a brilliancy "which was estimated at scarcely equal to α Lyræ." Mr. Clarke considers that ten per cent. loss will be a reasonable allowance for the reflections; and weighing some comparisons of α Lyræ without the lens, he gives it as the final result that the sun would have to be removed 103,224 times its present distance, for it to appear no brighter than the star referred to.

No review of this character can be complete without a chronicle of literary intelligence, and we shall therefore glance cursorily at the performances of 1863 and the promises of 1864, which can scarcely fail to be useful and interesting. An important reprint has been issued in France—a work by the celebrated astronomical king, Alphonso X. of Castile. It is divided into sixteen parts, commencing with a catalogue of the fixed stars. The royal author then treats of the apparatus and instruments necessary for observing the stars and *estrellas movediros*, or planets. Speaking of the constellations, he says of Ursa Major:—"Some astronomers have taken it for a wain with its pole, others say that it has the form of an animal which might as well be a lion, a wolf, or a dog, as a male or female bear. Here then are heavenly animals inhabiting that part of the sky where this constellation is to be found, and recognized by ancient astronomers because they saw four stars in a square, and three occupying a right line. They must have been endued with a better eyesight than ours, and the sky must have been very clear. Since they say it is a she-bear, let it be one. They were very lucky in being able to distinguish it." King Alphonso was evidently much in advance of his age to speak thus slightingly of popular tradition; his work is a worthy monument of his energy and genius.

Mr. J. R. Hind has brought out a third edition of his 'Introduction to Astronomy,' which is decidedly the best arranged elementary manual in the English or any other language. A new catalogue of standard stars has been issued from the Harvard College Observatory, Cambridge, U.S.A. It is a compilation of right ascensions from the best catalogues, of 152 stars, with copious constants for reduction, creditably arranged by Mr. Truman Henry Safford. The year 1863 has, amongst other events, witnessed the successful starting of what is, as far as we have been able to ascertain, the first purely astronomical periodical ever issued in England. The 'Astronomical Register' occupies a field hitherto a wide waste, and deserves to find a place on every astronomer's table. The Rev. R. Main, Radcliffe observer at Oxford, has recently published a 'College Manual of Physical Astronomy,' designed for the use of students. After a long delay, rendered necessary by the discovery of certain collateral errors, the second portion of 'Bessel's Zones' has just been published in a handsome volume, at St. Petersburg. It will be recollected that Bessel observed a large number of stars lying between 15° S. and 45° N., down to the ninth magnitude inclusive; his observations having been left unreduced, the task was undertaken by the St. Petersburg Academy of Sciences, which entrusted the work to the hands of M. Weisse. The first portion, comprising 31,085 stars, lying within 15° on either side of the equator, was given to the world in 1846; but the second, containing 31,445 stars, lying in a zone extending 30° northwards of the parallel of 15°, for reasons above stated, did not appear till 1863.

At the head of literary announcements undoubtedly we must place a new edition of Admiral W. H. Smyth's world-renowned 'Cycle of Celestial Objects.' This book, long out of print, being constantly asked for, its venerable and gallant author decided some time since to reissue it with such alterations and additions as twenty years made requisite. The new edition is now in progress, the more laborious part of it having been undertaken by the Admiral's accomplished son-in-law, Mr. Isaac Flitcher, of Tarn Bank, Workington.

Though Mr. Carrington has abandoned the observatory for the brewery, his important Redhill results will nevertheless be made available,—so far at least as regards his solar-spot observations, which are now in a forward state for publication.

The Obituary of 1863 happily contains no more leading names than Edward Josiah Cooper of Markree, Esq., and ex-M.P. for the county of Sligo; Virgilio Trettenero of Padua; J. W. H. Lehman of Göttingen; and M. Weisse of Cracow.

III. BOTANY AND VEGETABLE PHYSIOLOGY.

The attention of the French government has been called to some experiments of M. Hooibrenk, a native of Holland, for obtaining, by artificial fecundation, a more abundant crop of cereals, vines, and fruit trees. These experiments have been carried on at Sillery, near Rheims, on the property of M. Jacquesson, the well-known wine-grower. They are simple and inexpensive: the apparatus employed in the case of cereals being a cord of from 25 to 30 yards long, upon which is fastened a stiff woollen fringe, about ten inches in length, the hanging threads of which touch one another, and have small shot attached at short distances. At the time of flowering, this apparatus is passed over the crop so as to brush it lightly, an operation which employs three persons, a man at either extremity, and a child to hold up the cord at the middle. The object of this operation, which has to be repeated three times at intervals of about two days, is to scatter the pollen, and bring a larger quantity of it into contact with the pistils, and thus to ensure fecundation on a larger scale than is done by the ordinary operations of nature. The whole apparatus costs only five or six francs, and the labour employed is also very cheap, while the results have shown a vast increase in proportion. A modification of the process, as applied to vines and fruit trees, has also been followed by marked improvement in the crops; and, as a consequence, two commissioners, named by the Minister of Agriculture, have visited the scene of the experiments during the past summer, and as they have been carried on simultaneously with the ordinary system of farming, a comparison of the results shows the advantages given by the "Méthode Hooibrenk" as follows:—

	Hooibrenk System. Kilogrammes.	*Old System.* Kilogrammes.
Wheat	31	21
Rye	25·5	16
Barley	24	16
Oats	17	12

The Commissioners recommend a methodical examination into the subject, and the Emperor has decided that such an examination shall take place on the imperial farms of Fouilleuse and Fontainebleau.

Dr. F. Hildebrand, of Bonn, observing that in some tropical orchids, cultivated in the Botanic Garden, he found no ovules in the ovarium of the expanded flower, and that, nevertheless, he saw the enlargement of the ovarium after having applied the pollen to the stigma, has been led to make some interesting experiments upon this curious point, which has not escaped the notice of previous botanists. Observations on thirty different species of orchids proved that in the recently expanded flowers of orchids the ovules are never fully developed, while in some species, indeed, even the placentæ are not yet fully developed. After the application of pollen to the stigma, the enlargement of the ovarium begins, and before the pollen-tubes reach the placentæ or ovules. The tubes of pollen, therefore, have no direct influence upon the original development of the ovules, but they act first on the enlargement of the ovarium, and by this enlargement indirectly on the ovules. Dr. Hildebrand deduces from all his experiments that in the formation of the fruit of orchids, the pollen acts in two different ways: on the one hand it effects the enlargement of the ovarium, and the development of the imperfect ovules without the pollen tubes directly touching the ovules; on the other hand it impregnates the ovules, directly touching the embryo-sac, and determining the development of one germinal corpuscle into an embryo. This independent action of the pollen upon the ovules is probably not peculiar to orchids, although it has thus been noticed in that family, but the remarkable facts lately pointed out by Darwin in his 'Fertilization of Orchids,' as well as those just referred to, bear singular testimony to the acumen of the late Robert Brown, who foresaw that a patient examination of the structure and action of the remarkable sexual organs of this family would be more likely than any other means to elucidate the difficult subject of generation in Phanerogamic plants.

A remarkable confirmation of Mr. Darwin's views of the fertilization of orchids by insects is afforded by a South African species (*Disa grandiflora*), described in the recently issued Linnæan Journal. None of these South African species have hitherto been examined in relation to their manner of fertilization. In *Disa* the labellum is greatly reduced in size, and the posterior sepal large, forming a spur containing nectar. The nectary thus stands behind the stigma and pollen masses, in a directly opposite position to that which it occupies in other orchids. Nevertheless, fertilization is effected by insects, by a very slight change in the form of the two upper petals, and in the position of the viscid discs of the pollen masses, which are widely removed from each other, and face outwards from the labellum towards the margin of the column. The upper sepal and two upper petals enclose the column, so that insects, to reach the nectar, are compelled to approach the flower in front; but as the column stands in the way of the nectary, insects must push their proboscis or head on either side of it, in order to reach the nectar. In Disa the caudicles of the pollinia do not undergo the movement of depression, as described by Mr. Darwin, in most British orchids, but the caudicles are naturally crooked. In this plant therefore, notwithstanding the remarkable difference in the position of the nectary, every part of the flower, by the aid of very slight modifications, has become so neatly co-ordinated to ensure fertilization through the agency of insects.*

In connection with the subject of fertilizing processes, a remarkable arrangement has been noticed, by F. Cohn of Breslau, in thistles. The five anthers cohere, forming a tube. At the time of flowering this tube is shut in at the top, enclosing the style. About this period

* It may be mentioned, in connection with the interest excited by orchidaceous plants of late, that M. F. G. Beer has lately published an elaborate work at Vienna, 'On the Morphology and Biology of the Orchidaceæ;' and some remarks by Prof. Asa Gray, on the Fertilization of some of the North American Orchids, will be found in 'Silliman's Journal' for September last.

the anther tube rises to about four millimetres above the extreme points of the corolla, and if the same be touched, pollen, in lumps, issues from the summit, the anther-tube at the same time undergoing a remarkable twisting. After a short interval this is repeated. The style gradually becomes elevated above the summits of the anther-tube, and by the time it projects about four or five millimetres beyond, the irritability has completely disappeared, having lasted at the most about twenty-four hours. When the styles are visible it is too late for instituting experiments. These phenomena are produced solely by the contraction of the filaments of the stamens, which on each touch instantly contract, and after a little, resume their former length. The expulsion of the pollen depends upon the anther-tube being drawn downwards upon the style by the contracting filaments, and then pushed up again.

The subject of the functions of vascular tissue causes some difference of opinion among botanists, some saying that although containing air at most seasons, they are filled with sap in spring, while others affirm that when once formed they contain only air. M. Gris has applied Fehling's solution, which deposits a red precipitate when boiled with a very small quantity of glucose, thus indicating the presence of an essential element of the sap. On plunging for a few moments into such a boiling solution, thick fragments of the wood of chestnut, beech, poplar, laburnum, &c., at the commencement of spring, and afterwards, cutting thin sections for the microscope, the precipitated oxide of copper is found clothing the inner face of the large vessels, and forming reddish threads visible to the naked eye. The precipitate is also abundant in the cells of the medullary rays, whence M. Gris concludes that the so-called lymphatic vessels (at all events in spring) contain a sap either identical with, or closely analagous to, that found in the cellular elements of these stems. The spiral fibres of the reticulated, annular and spiro-annular, and other similar vessels of herbaceous plants, also present, in their interior, the red precipitate when similarly treated.

With regard to one class of vessels concerning which very considerable modification of opinion has been necessary since their first discovery by Schultz, *viz.* the laticiferous tissue, M. Lestiboudois has instituted a systematic series of experiments, the results of which he communicates from time to time to the 'Comptes rendus.' He has established beyond doubt the existence, in certain plants, of vessels containing coloured liquids, and that these *vasa propria* are not mere excavations in the tissue, permeated by a thread of granuliferous tissue, but that, though probably at a late period, a delicate wall is developed, which constitutes it a distinct vascular system, though not in all points a counterpart of that of the blood-vessels of animals; nor do they fulfil precisely the same purpose. While not, however, regarding the contractility of these vessels as proved, he considers that he indisputably makes out a circulation of the liquid contents, not regularly from one point to another, but in such a manner that the granules are driven into all the ramifications of a more or less complicated network. In addition to the true vessels which contain the proper juices of plants, and which may either be long rigid tubules without anastomoses, or thin flexuose, and branching, with frequent inosculations, there are certain reservoirs or utricles, and others in the form of intercellular passages (or meati), which present themselves in the form of slightly branching vessels, constituting now and then a sort of framework around cells—and some of which are simply irregular cavities produced by laceration. In another communication, M. Lestiboudois enlarges on the subject, and adds that this imperfect vascular system is not met with in the generality of plants, nor in all parts of the plant in which they occur—nor, therefore, is the laticiferous juice an essential element in the growth of plants. M. Lestiboudois refuses to recognize two categories of coloured juices, essentially differing from one another,—the one special, scented, and excrementitial, and the other vital and alimentary; and further, is of opinion that the terms *latex* and *laticiferous* vessels should be abolished, because they perpetuate an erroneous idea, by assigning to plants those centralized functions which they do not really possess, but which are peculiar to animals.

It is always an interesting matter to receive confirmation of the natural affinities of structure in groups which have already, from a general community of characters, been arranged by botanists in what are termed *natural orders*; and the researches of Mr. Gulliver among the minute crystals called *raphides* existing among the tissues of some plants tend to this result. Mr. Gulliver has distinguished the acicular crystals (or true raphides) from another class of crystals which occur among Phanerogamia, commonly in a more or less globular congeries, either naked or within a cell, and which he proposes to call *Sphæraphides*. The distribution of this latter class of crystals appears to be especially characteristic of the Caryophyllaceæ, Geraniaceæ, Paronychiaceæ, Lythraceæ, Saxifrageæ, and Urticaceæ, so that he has never failed to find them in a single species of these orders. But inasmuch as he further believes that few, if any, orders could be named in which Sphæraphides do not exist, it is questionable how far they might be available as botanical characters. With true raphidian tissue, however, the case is different; they occur so regularly and plentifully in some plants, and so sparingly or not at all in others, that they afford good characters by which certain orders may be readily distinguished from their allies of other orders. Thus if we confine the word *raphides* to the needlelike crystals commonly occurring in bundles, it may be the expression of a more universal diagnosis between such orders as the Onagraceæ and their next allies (and yet no less simple and sure), than any single character hitherto employed; and we could determine the affinities and contrasts of certain plants by a method at once easy and practical, and in the absence of those parts heretofore exclusively used for the descriptive distinctions. Mr. Gulliver speaks in a later communication thus strongly:—" No other single diagnosis for the orders in question is so simple, fundamental, and universal as this; and the orders to which it applies should be designated *raphis bearing* or *raphidiferous.* Besides Onagraceæ, Dioscoraceæ, Araceæ, and Asparagaceæ are spoken of as truly raphidiferous orders.

M. B. Corenwinder has been making a series of observations upon the expiration of leaves by day and night. He finds that the amount of carbonic acid exhaled at night varies with the temperature and ceases at zero; nor is the property of absorbing carbonic acid and again decomposing it found in very young leaves and buds. Adult leaves, however, never exhale carbonic acid in the open air, and when they receive a full supply of light from all parts. The question whether leaves coloured red, brown, or purple, possess the same properties as green leaves, has also occupied his attention, and he asserts that they differ in nothing from green plants in regard to the property of absorbing carbonic acid under the influence of light, and exhaling it in darkness. It is therefore inexact to say, in an absolute manner, that it is by their *green* parts that leaves decompose carbonic acid under the influence of sunlight.

The abundance of minute organisms found at deep-sea bottoms in the Atlantic and elsewhere, and the remarkable facts disclosed by Dr. Wallich's deep-sea soundings in the expedition of Capt. M'Clintock, gave some colour to the idea that the vegetable Diatomaceæ exist in a living state at great depths, and Dr. Stimpson, an energetic young naturalist connected with the Smithsonian Institution at Washington, who examined the specimens taken at the depth of 2,700 fathoms, in latitude 46 N. and longitude 168 E., by Lieutenant Brooke, found some startling appearances. The armature consisted of three quills, each about three inches in length, fastened together, and placed in such a position that, when the lead struck the bottom, the quills would be forced perpendicularly into it, and thus become filled with mud from a stratum a few inches below the general surface of the sea-bottom. One of these quills, *cut in two in the middle,* contained Diatoms, apparently Coscinodisci, which appeared to Dr. Stimpson to be undoubtedly living, judging from their fresh appearance and the colours of their internal cell-contents. Dr. Wallich, however, argues that although the soft parts are retained in specimens obtained from extreme depths, they differ materially both in aspect and quality from those of Diatoms known to be living. Such Diatoms never present a trace of locomotion, which is so tenaciously retained by Diatoms under all other circumstances. Moreover, the Coscinodisci, which constitute the largest proportion of Diatoms found in deep-sea deposits, are essentially inhabitants of shoal water. They do not live imbedded in mud, but the upper waters teem with their frustules. Dr. Wallich therefore inclines to answer the question decidedly in the negative.

IV. CHEMISTRY.

In commencing the Chronicles of the progress of Science for the last few months, it becomes necessary to exercise considerable care in the choice of subjects to be mentioned, so as to avoid on the one hand the omission of anything likely to interest a large section of our readers, and on the other hand to keep our pages from being overburdened with a mass of facts, important, no doubt, to the student of one special science, but of no interest to those outside the circle. This precaution is especially necessary in a science like Chemistry, in which not only does every month bring forth new discoveries, but every week—nay, every day is marked by some valuable fact. Our readers must not therefore expect to find every fact, even those most important, recorded in these chapters, but it will at the same time be our endeavour so to select our topics as to constitute these pages a truthful mirror of the general progress of Science.

There have been few periods more fruitful in important chemical discoveries than that comprised within the last few months. Two new metals have been announced as belonging to the already numerous family of elementary bodies, one of which has been literally brought to light by spectrum analysis—that powerful analytical process which has already given us cæsium, rubidium, and thallium. The new arrival is due to the labours of two German chemists, F. Reich and T. W. Richter.* They were examining some impure chloride of zinc obtained from two Freyberg ores, in the expectation of finding thallium present. In the spectroscope no green line was seen, but the authors remarked an indigo blue line, which was till then unknown. Upon isolating the conjectural substance in the form of chloride, they found that it gave this blue line, so brilliantly sharp and persistent, that they at once came to the conclusion that it belonged to a hitherto unrecognized metal, to which they accordingly gave the name *indium.* In their memoir the authors give the characteristic properties of the new metal, which appears somewhat to resemble zinc, and describe several of its compounds. The discovery has been confirmed by other chemists of eminence, and there now appears to be no doubt whatever as to its accuracy. The same cannot be said respecting the new metal claimed by M. J. F. Bahr.† In the analysis of a highly complicated mineral, from the island of Röusholn, containing nearly all the metals of the aluminium group, the author obtained about 1 per cent. of what he supposed was a new addition to this numerous family. He proposes for it the name of *wasium.* The existence of wasium as a simple body has been since disputed by M. Nicklès, ‡ who asserts it to be a mixture of the known bodies yttrium, didymium, and terbium.

* 'Journal für praktische Chemie,' bd. lxxxix. p. 441.
† 'Annalen der Physik und Chemie,' vol. cxix. p. 572.
‡ 'Comptes Rendus,' Nov. 2.

The already known elementary bodies are being gradually brought within the domain of spectrum analysis. Phosphorus, which has been long known to communicate, under some circumstances, a green colour to flame, has been shown by MM. Christofle and Beilstein * to possess a very definite spectrum, consisting of three distinct green lines. This new test is likely to be of considerable use, as, by its means, this deleterious body has been shown to exist in many samples of good commercial iron, which were supposed to be free from this impurity.

Our knowledge of the recently discovered element, cæsium, has been greatly enlarged by its discoverer Bunsen.† For the original isolation of this interesting alkali, nearly 100,000 lbs. of the mineral water of Dürkheim were evaporated down, yielding, however, only 30 to 40 grains. He has since determined the atomic weight to the metal with great accuracy upon a somewhat larger quantity, and has obtained the same number as those given by Messrs. Johnson and Allen, ‡ namely 133.

M. Rose has announced a no less important discovery than that of an entirely new series of metallic oxides.§ In his memoir he proposes a new nomenclature which, were it generally adopted, would be of great convenience to chemists. The new series, which he has discovered, consists of 1 of metal with $\frac{1}{4}$ of oxygen, and this he proposes to call *quadrantoxide;* the compound of 1 of metal with $\frac{1}{2}$ of oxygen, variously named the suboxide or the protoxide, he proposes to call *semioxide;* the compound of equal atoms of metal and oxygen he calls *isoxide;* the compound of 1 of metal to $1\frac{1}{2}$ of oxygen retains its name, *sesquioxide;* whilst the ordinary binoxide is called the *diploxide.* Only one quadrantoxide has as yet been formed and analysed, but reasons are given for supposing that the suboxide of silver is really the quadrantoxide, and it is very probable that quadrantichlorides of the alkali metals are also known. As might be expected from their composition, these new oxides are difficult to prepare, and are easily decomposed.

The mysterious body ozone, respecting which so much has been done but so little is known, is still occupying the attention of chemists. Schönbein has already shown that this body is formed when evaporation takes place, and M. Morin ‖ considers that the good effects observed when water is artificially evaporated during the ventilation of rooms, may be due to the formation of a certain quantity of ozonized oxygen. English writers on Ventilation always advocate the introduction of a certain amount of moisture into the air supplied to inhabited places, and this has been well carried out in the ventilation of the Houses of Parliament.

Few chemical manufactures have been developed so much of late years as that of the barium compounds, and its prospective applications are most numerous and important, although at the present day their

* 'Comptes Rendus.' † 'Phil. Mag.,' vol. xxvi. p. 241.
‡ 'Silliman's Journal,' vol. xxxv. p. 94. § 'Poggendorff's Annalen.'
‖ 'Comptes Rendus.'

use seems to be confined to the manufacture of green fire. M. Kuhlmann has lately entered very largely into the manufacture of different compounds of barium, with a view to their commercial introduction. The absorption of oxygen from the air by red-hot baryta, and its subsequent release at a higher temperature, in the form of pure gas, could be made of the greatest importance to metallurgical and furnace chemistry. A cheap method of making peroxide of barium would place us in possession of the valuable peroxide of hydrogen, which would be of incalculable use as a disinfectant, and also in many manufacturing processes. To the industrial chemist cheap caustic baryta would entirely revolutionize the alkali manufacture, whilst for many purposes it would supersede the ordinary alkalies. In the manufacture of crystal-glass, lead, the most costly ingredient, could be even now economically replaced by a barium compound, provided a few preliminary difficulties were overcome. Nitrate of baryta can also be economically employed in the preparation of blasting powder; the chromates of baryta can in many cases replace the more costly chromates of potash, and the same may be said of the ferrocyanides, all of which are largely used in dyeing. These are some of the more important applications of this earth, but an immense number of minor uses has also been proposed, and there is little doubt that it will shortly become as valuable in industrial as it already is in analytical chemistry.

The extraordinary prolificness of some organic chemists in the discovery of new bases, will cease to be surprising after the perusal of a paper by Mr. Broughton,* in which it is shown that the known general processes for their formation are competent to produce several sextillions of new ammonias. As most, if not all, of these compounds only require for their production certain known agents to be placed in contact, it is evident that chemists need not debar themselves from the title of original discoverers for lack of virgin soil on which to work.

The value of the element bromine in the arts and manufactures is daily increasing, and were its price reduced, its importance in many industrial operations can scarcely be over-estimated. Hitherto the only source has been sea-water, where it exists in the form of bromide of magnesium, one part of this salt being dissolved in 100,000 parts of water. Recent experiments, by M. Roux,† show that the water of the Dead Sea is more than 100 times richer in bromine than ordinary sea-water. Already we hear of proposals for the establishment of a factory near the Dead Sea, for the separation of this element. It is much to be desired that this inexhaustible store of so valuable an agent should be utilized.

Perhaps the most important point to determine in the analysis of a drinking water is the presence of nitric acid, as this body is so closely connected with putrescent organic matter. Hitherto, however, few chemists take note of it, owing, doubtless, to the difficulties which beset its detection when very dilute. Mr. R. Kestings ‡ has now

* 'Chemical News,' vol. viii. p. 245.
† 'Comptes Rendus,' vol. lvii. No. 14.
‡ 'Annalen der Chem. und Pharm.'

shown that the alkaloid brucine is a most delicate test for nitric acid, being coloured rose-red by water, containing only the 100,000th part. It is to be hoped that more attention will in future be paid to the varying proportions of this acid in potable water, and that the warnings given by its presence will not be disregarded.

The subject of pure water for household purposes is so important that we again recur to it, to notice an invention of Dr. H. Schwartz, which appears to remedy perfectly the effects of the employment of lead pipes and cisterns. He converts the inner surface of the metal into an insoluble sulphide by boiling in it a solution of sulphur in soda. The result is that the water is perfectly kept from contact with the metal, and will be as free from contamination as if it had been passed through a glass pipe.

Some curious results of the inhalation of the vapour of glonoine (an oil obtained by the action of nitric acid on glycerine) have been given by Mr. Merrick.* It has long been known that this body produces violent headache, but these experiments show that it is a most powerful agent in its physiological action. In one case the fortieth part of a drop dissolved in spirit was swallowed on a piece of sugar. In two minutes the pulse had risen considerably, being accompanied with a violent headache. This continued for nearly half-an-hour, when the symptoms passed off. At another time, when a quantity of vapour was accidentally inhaled, the headache became almost intolerable, and was accompanied by a good deal of faintness and exhaustion, intolerance of light, and a feeling of great general distress and alarm. The violent toxical effects show that glonoine is a powerful poison, and, like most agents of this kind, will doubtless be employed in medicine.

The application of gun-cotton as a substitute for gunpowder in warfare has occupied the attention of a committee of scientific men for some time past. General Von Lenk, of the Imperial Austrian Artillery, has invented a system of preparation by which gun-cotton has been made practically available for warlike purposes. The committee have had the advantage of personal communication with the General, and in the report, which will shortly be issued, an abstract of which having been communicated to the British Association at Newcastle, we are promised a vast amount of information of the most important character. General Von Lenk has shown that perfect gun-cotton is a definite chemical compound; he has given accurate processes for its manufacture, and for the removal of all extraneous matter and traces of free acid. As thus prepared, it is no longer liable to spontaneous combustion, it can be stored for any length of time without deterioration, it is not impaired by damp, and may be immersed in water without injury, its original qualities returning unchanged when allowed to dry in the air. These are valuable properties, and when we add to them the absence of smoke, the entire freedom from fouling, the innocuous character of the products of combustion in com-

* 'Silliman's Journal,' vol. xxxvi. No. 107.

parison with those of gunpowder, and the far inferior heat imparted to the gun itself, it will be seen that the advantages attending the employment of gun-cotton, are so many and so important as to call imperatively for the fullest investigation.

From gun-cotton to armour-plated ships is a natural transition in these warlike days. Science seems to be at fault on the subject of the preservation of iron plates from oxidation and fouling. One of the best processes, that has yet come under our notice, is due to Messrs. Johnson and Calvert. They propose to coat the iron with a thin layer of metallic zinc, as in the ordinary process of galvanizing. Their results prove that the film of zinc exercises a great protective power against the corrosive action of sea-water; upwards of a year's exposure showing that four or five times as much corrosion took place in the case of uncoated as with galvanized iron plates. Whether galvanizing would prevent fouling, remains to be seen; we suspect it would rather aggravate this evil.

V. GEOLOGY AND PALÆONTOLOGY.

There is perhaps more difficulty in describing the periodical progress of Geology, than there is in recording that of any other science. The exactitude of the advance is less decided, the views set forth more speculative, and the facts given more open to objection or discussion, than is the case in any other department of intellectual investigation. In Chemistry, the discovery of an element or of some previously unknown compound, gives a fixed and tangible point from which to go onward to further knowledge. Every step is a permanent score in the continuous tally. So the discovery of a comet or a planet, or a nebula, or more exact measurements of angles, or of distances, or the detection of errors of observation, or calculations or the revelations of increased telescopic powers, all yield for Astronomy definite and incontrovertible results, and it is only in the special sphere of absolutely speculative Astronomy, that there is any uncertainty whatever. So, too, in Botany, a new flower, or a flora of some previously unnoticed region, is so much substantially added to the previous knowledge, so much gain which can be appreciated and recorded. But in Geology, we have to deal with the rags and shreds of former ages and former beings, nothing whole or entire,—every relic has to be dug out of the *débris* and ruins, which we have, as it were, first to clear away before we can get a glimpse of any treasures remaining beneath, and when we find these they are damaged and mostly broken fragments which we have to join and fit, and put together, to get, in the best way we can, some general notion of what they originally were. Thus it is a new geological idea gets started, and is discussed, opposed, supported, until finally substantiated or disproved; in short, it is only after a contest that, generally speaking, any progress in this science is admitted. In a quarterly summary of the nature of the present article, there must necessarily therefore be, as a rule, less definiteness and more hesitation and uncertainty than one would wish, but notwithstanding this inherent difficulty in the task, it is perfectly possible to give a concise and clear account of what is new and what is changing; but it must be more or less the newness of theories as well as of facts, bearing always in mind that geological facts are first provisionally accepted on the reliability of the observer, and are often open not only to questioning but to reversal. Thus for many years the older crystalline or metamorphic rocks were regarded as owing their characteristic structure to their contact with other heated or so-called igneous rocks,—such as granite was supposed originally to have been, constituting the lower zone at least of the crust of the planet we inhabit.

For some time past, some of our most acute and practical geologists have more than doubted the old doctrines, and our own Sorby, by detecting the existence of steam-bubble cavities in granite, decisively proved that dry heat had not been the cause of its crystalline change. Dr. Rubidge, who has done so much good geological work at the Cape of Good Hope, also years before threw doubts on the heat-origin of the changes exhibited by the metamorphic rocks, by stating the occurrence, in the district of Port Elizabeth, of intercalated metamorphosed strata with unchanged sedimentary beds above and below them. Such examples have since been from time to time not unfrequently timidly recorded, but they are now being more boldly noticed. Dr. Hitchcock, very lately speaking of the granites of Maine, in the Northern States of America, regarded the old theory that granite was once melted matter thrust into every crack of the overlying strata as erroneous, and substitutes the aqueo-igneous explanation of a plasticity of the original materials by means of steam, the primal structure of the rock being thus obliterated, and a new crystalline condition induced. He thinks that granite may thus have been formed out of schists, and these originally from shales and sandstones, and contends that it is "only an example of metamorphism carried to its utmost limit—carried far enough to obliterate all traces of stratification, foliation, and lamination." Observation, he further claims, shows that granite does not always constitute the axes of mountains, but that it lies between strata, and instead of having been the agent by which they have been lifted up, it has partaken of the general movements which have resulted from general causes. In York and Oxford counties, in Cumberland, and Franklin, he notices the intermixture of granite with bands of sedimentary strata, and constantly speaks of it as "comporting itself like a stratified rock." That of Buckfield is mostly in the form of large beds and veins, and at Woodstock mica-schist is seen lying beneath it. Again, in the south-eastern counties of Maine, granite at the south end of Bluehill Neck, overlies strata of gneiss and mica-schist; and in the Kennebec region it is said that in one of the Hallowell quarries there are twenty-six different sheets, varying from eight inches to four feet in thickness, and that "these sheets are arranged like strata." In Canada, too, even the granites of the Lamentian and Lower Silurian age appear in every case to be indigenous strata altered *in situ*, and still retaining evidences of their former stratification. These instances might be greatly multiplied not only in the American States, but by numerous examples in Europe, and probably by some in our own islands. Indeed nowhere is there any evidence of the hypothetical granitic substratum which, in even not yet very ancient treatises on Geology, we were taught to believe constituted the "backbone of the earth." Even one such example of interstratification would have gone far to throw a doubt upon the purely igneous origin of granite, but when instances become so multiplied the doctrine seems no longer tenable. Dr. Hitchcock argues forcibly against it. The dry heat, he contends, that would be required to keep granite melted must be intense, for it resists the most powerful blast-furnaces, and even if, as melted matter, it were injected in close contact with the cold walls of fissured rock, it must have cooled before it had time to penetrate all the narrow crevices in which it is found in the form of veins. Again he urges that, if crystallized from such fusion, the quartz would have been consolidated and crystallized first, because it is less fusible than the mica and feldspar; instead of which its condition in the structure of granite shows it to have been the last consolidated of the ingredients, for if anyone examines a piece of granite, he will see the crystals of mica and feldspar are often perfect, while those of quartz are never so. The quartz is always in the amorphous state, and the sharp crystals of mica and feldspar seem to cut into it, as is beautifully seen in graphic granite—an appearance which cannot be accounted for in any other way than that the mica and feldspar crystals were formed first, and that the quartz subsequently filled up the interstices. But such an admission is fatal to the doctrine of a cooling down from fusion by dry heat because, in that case, the quartz should have been, as we have said, the first to crystallize. Moreover, that granite contains not a few hydrated minerals, or such as contain water in their composition, is another fact telling also against the old opinions.

In the matter of metamorphic rocks Mr. Sterry Hunt has also been continuing those valuable theoretical and practical researches of which he gave us two instalments in 1858 and 1859. Those articles were remarkable for the great ability of his attempts to indicate the ages of granites by the amounts of soda or potash they contained, and during the present year he has given to the world another elaborate paper, read before the Dublin Geological Society, on the chemical and mineralogical relations of the metamorphic, or, as they have been as commonly called, the crystalline primitive rocks. It is not indeed so very long since all rocks of this character were included in the common designation of primitive, and were considered to belong to a period anterior to all the fossiliferous formations, and indeed to the existence of life, either vegetable or animal, on our earth. To express this idea, the term "azoic" was invented, while "palæozoic" was given to the Silurian rocks, as containing the supposed first traces of animated existence, or the "oldest life-forms," on our planet. Some geologists still consider the Lower Silurian or Cambrian zone to be the first burial-ground of organic remains, and that no previous creation of animated beings or vegetation had taken place. Not only, however, do the imperfectness of the animal series, and the superior organization and degrees of development of the fossil genera and species met with in the lowest of the palæozoic rocks, as they are at present restricted in their downward horizons, militate against such a view by indicating the *previous* existence of zones of *previous* creations, and causing the reflective mind to regard these earliest palæozoic fossils as only the shreds and patches of still earlier life-garments of our earth, but they seem also to make the inquiry lack the aid of the chemist and mineralogist to tell us whether, in the present altered state of such rock-masses as are older than the palæozoic beds, there can be detected in the component materials any ingredients which owe their presence to the former existence in those masses of organic remains.

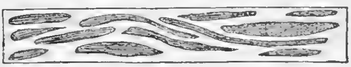
It is exactly with this question that Mr. Sterry Hunt has occupied himself, and has made some excellent attempts to ascertain whether, in the absence of organic remains, or of stratigraphical evidence, there are any means of determining, even approximately, the geological age of a given series of crystalline stratified rocks—in other words, whether the chemical conditions which have presided over the formation of sedimentary rocks have so far varied, in the course of ages, as to impress upon such rocks any marked chemical and mineralogical differences. To some extent it does appear possible to work out such a problem in respect to definite cases, although as yet no one could see the way to the generalization of a rule; indeed, in the ever-variable and divergent conditions of our planet's surface, and the different combinations and oppositions of the atmospheric influences which have been, through all periods, carrying on their effects around it everywhere, it seems impossible this ever should be accomplished. To arrive at any such indicative result in the case of unaltered sedimentary formations could not be accomplished without multiplied analyses, and even then the conclusions might not be absolute. It is different, however, when chemical or mineralogical changes have set in, for the natural affinities of some elements for others render definite the results of such combinations, and so we find that the crystalline minerals which are formed are definite in their composition, and vary with the chemical constitution of the sediment from which they were derived. Therefore it is that Mr. Sterry Hunt thinks these crystalline minerals of the metamorphosed rocks may become to a considerable extent, to the geologist, what organic remains in the unaltered rock are to the palæontologist—a guide to geological age and succession. The feldspars, for example, composed mainly of silica and alumina, combined with the silicates of potash, soda, and lime, do, in their spontaneous decomposition, part with the latter ingredients, and there remains behind, as a final result, a hydrous silicate of alumina, which is kaolin, or clay. Now, where potash and soda feldspars are associated, it has been repeatedly observed that the soda-compound is much more readily decomposed than the potash-compound, and that the soda-feldspar becomes perfectly friable, and fit for a further reduction into clay before the orthoclase, or potash-feldspar, has been altered at all. The result of combined chemical and mechanical agencies acting upon rocks containing quartz, with orthoclase and such soda-feldspars as albite and oligoclase, would be thus a sand-compound of quartz and the less destructible potash-feldspar. The mechanical agency might be air or water; if the latter, there would be found suspended in it a fine clay, consisting mostly of the partially decomposed soda-feldspar. Now this process of destruction is evidently one which must go on in the wearing away of rocks by aqueous agency—just the agency which is the most important in such inquiries as the present, because most intimately associated with the deposition of the sedimentary rocks. It is easy to see how, by such partial destruction of the primal rocks, quartz is for the most part wanting in those which contain a large proportion of alumina, while it is abundant in those in which potash-feldspar predominates. So long as this decomposition of alkaline silicates is sub-aërial, both the silica and alkali are removed in a soluble form. But as immense quantities of undecomposed fragments of the primal rock are detached by atmospheric causes, and carried down to the sea, which acts upon these with more power even than upon the surfaces of the rock directly exposed to its influence, the process is often sub-marine and beneath the sea-bottom in the midst of sediments containing the carbonates of lime and magnesia. When the silicate of soda is, under such circumstances, set free, it reacts upon those earthy carbonates, or upon the chlorides in the sea-water, and forms in either case a soluble soda-salt, and insoluble silicates of lime and magnesia.

The sources of the carbonates of lime and magnesia in sedimentary strata, have been the decomposition of silicates containing those bases, such as lime-feldspar and pyroxene, and the action of the alkaline carbonates formed by the decomposition of feldspars upon the chlorides of lime and magnesia originally present in sea-water, but which have been by this process in subsequent ages, in great part replaced, by the resulting chloride of sodium. A curious result as showing the sea to have not been originally as salt in the primeval era as it is at the present epoch, and giving, if the total could be ascertained, the clay or aluminous silicate of the earth's crust, as a measure of not only the quantity of salt added to the primitive ocean, but of the amount of the carbonic acid removed from the air, and of the carbonates of lime and magnesia precipitated. As the coarser sediments in which quartz and orthoclase prevail are permeable to infiltrating waters, their soda, lime, magnesia, and oxide of iron will be gradually removed, leaving at last only silica, alumina, and potash—the elements of granite. On the other hand, the finer marls and clays, resisting the penetration of water, will retain their soda, lime, magnesia, and oxide of iron, and having an excess of alumina, will by their metamorphism give rise to basic lime and soda-feldspars, to pyroxene and hornblende—the elements of diorites and dolerites. In this way, the long-continued operation of chemical and mechanical causes would naturally tend to divide all the crystalline silico-aluminous rocks of the earth's crust into two types, exactly corresponding to the two classes of so-called igneous rocks, the trachytic and pyroxenic, which geologists have supposed to have been derived from two distinct imaginary magmas beneath it. When, however, ordinary sedimentary strata have been rendered crystalline by metamorphism, their future alterability becomes difficult, because their permeability to water is so enormously diminished, and it is not until they are once more broken down to the condition of soils and sediments, that they become again subjected to such important chemical changes as we have described. Hence, the mean proportions of alkali and alumina in the composition of the clay sediments of any geological period will depend not only upon the age of the formation, but upon the number of times its materials have been broken up, and the periods during which they have remained unmetamorphosed and exposed to the action of infiltrating waters. Such are the general principles which in this excellent paper Mr. Hunt brings to bear upon the actual state of the metamorphic rocks of Canada from the Carboniferous to the Lower Silurian, and down to the azoic rocks and granite, even the veins of which he regards as formed like metalliferous veins by aqueous deposition in fissures.

The Sixth Annual Report of the Maine Board of Agriculture* recently circulated, presents a feature not so common in this country as it deservedly ought to be, an association of geological investigations with the practical pursuit of agriculture. Even in the first few pages on the application of fish-manure, and where we should have little expected it, we find practical hints from the geologist. Commenting on Mr. Bruce's endeavour to introduce this to us very objectionable and disgraceful appropriation of the most extensive source of animal food which nature supplies to mankind, Mr. Sterry Hunt recommends the combination of the fish-manure with calcined shale for the purpose of driving away insects from the plants to which it is applied. Distilling a black bituminous shale from Port Daniel at a red heat, the disengaged vapours were passed through a vat containing the fish, which by the continuance of the heat were ultimately reduced to a pulpy mass. The calcined shale, ground to powder, was mingled with this; the whole being then dried. Experiments made with the manure are reported to have given satisfactory results; it might be well if English agriculturists should pay some attention to the poorer kinds of bituminous shales which are met with in the British Isles, and even the refuse of the richer sorts, such as the Kimmeridge and the Glasgow shales, which have been used for making gas, might be in this way turned to a useful and profitable account, not necessarily for mixing with fish-manure, the use of which we have strongly deprecated, but for commingling with many other classes of manures, as the chief efficacy calcined shale possesses against noxious insects appears to be in the presence, or perhaps in the odour, of the bitumen it contains; for it is known that coal-tar applied to the interior wood-work in greenhouses has the effect of expelling those unwelcome intruders. Such bituminous sandstones as those of Caithness, might thus be turned to profitable account, and there are other

* 'Sixth Annual Report of the Secretary of the Maine Board of Agriculture.' Augusta: Stevens and Hayward, 1861–2.

rocks in various parts of our island, which, although not sufficiently rich for gas-making, contain quite sufficient bituminous ingredients for agricultural purposes, particularly the enormous beds of shale which are at present left untouched in our coal-pits. But it is not in incidental suggestions like this, valuable as they may be, that this Report shows in the strongest light the important relations existing between the geological structure of a country and the farming operations carried on upon it. So high has the Board of Agriculture of Maine considered the advantage of such knowledge, that it has directed a special survey to be made of the whole State, "believing that such a survey, ably conducted, would greatly tend to develope and improve its agriculture;" and urging at the same time "that the utility and value of such explorations are no longer doubtful." This preliminary Geological Survey has been executed under the direction of Mr. Charles H. Hitchcock, of Amhurst, with Mr. Goodall, of Saco, as chemist, and Mr. Houghton as mineralogist. By them the seaboard from Saco to Calais was explored, and excursions made into the interior, and to the islands; next through the north of Washington County to Holton, and thence to Bangor. Subsequently up the Penobscot river, down the Alleguish and St. John river to Woodstock, through the iron and slate region of Piscataquis County, the country around Mooschest lake and the Penobscot river. By these explorations and the use of the valuable observations previously made by Dr. Jackson of Boston, a sufficient idea of the geological structure of the slate has been obtained for the construction of a general map, to serve as a basis for future systematic and more thorough explorations. It is not our intention to follow through the report of this, as far as it goes, excellent survey, but to gather rather from it such new or remarkable purely geological phenomena, as may be worthy of particular notice. One of these is a condition of the pebbles in a conglomerate bed on the northern border of Washington County, which is very remarkable. The inclination of the strata is some 65° easterly; the strike being N. 8° W. The layers are sometimes contorted, and numerous narrow perpendicular veins of quartz cut across their bedding. But the peculiarity of the conglomerate consists in the distortion and curvature of the pebbles it contains, the general appearance of which is illustrated in the accompanying sketch. They appear as if they had been drawn out, curved, and pressed together by the forces to which they had been subjected.



Mr. Hitchcock considers there is no doubt of these pebbles having been curved since the consolidation of the rock in which they are embedded; and even goes to the length of asserting, that such elongated pebbles have been changed into the siliceous laminæ of talcose and micaceous schists, while the cement has been converted into mica, the talc of talcose schists, and feldspar. To effect the change of form of the pebbles, according to Dr. Hitchcock's views, the substances of which they are composed require to have been brought into a soft or yielding state like moistened clay, and then to have been contorted under the application of force or pressure; while to effect their still greater alteration into the laminæ of schists, he looks to the further continued action of chemical changes amongst the heterogeneous sedimentary materials in selecting and combining the different mineral atoms in their proper proportions to form the new crystalline masses.

Letting alone this last topic, and confining ourselves to the phenomena of contortion only, if these pebbles were of clay, we could understand their being softened; but if they are of limestone, sandstone, slate, or flint, it is very hard to believe they ever were softened after they were once solidified. The phenomenon is, however, exceedingly remarkable, and not yet perhaps clearly explainable. It would seem to belong to the same class as the Nagel-Flue of Switzerland, so successfully investigated by Mr. Sorby, or as the nodular bands of limestone in the Wenlock Formation, to which attention has been drawn by M. La Touche and Mr. Salter. If anyone examines the ordinary condition of a conglomerate, or the nature of a sea-beach, the more or less rounded pebbles will be found simply piled one upon the other, very rarely are any elongated or flat, except when the pebbles are of slaty-rocks, and never bent unless they happen to be the fragments of naturally-curved strata. In no case are there any corresponding lines of contortion, such as shown in the woodcut, which represents a section of the Weston Conglomerate, in which the pebbles are drawn out and flattened, and compared by Dr. Hitchcock to spheres of clay pulled out into prolate-spheroids; and the pressure of an immense weight might, he thinks, be so continued as to elongate a pebble of clay into the resemblance of a lamina of quartz in gneiss. He makes intelligible the nature of the Weston Conglomerate by supposing that amongst many balls of clay some were plastic and some hard, and that these were then subjected to such a pressure as should pull out and flatten all the plastic ones, which would thus have their forms modified by the unyielding ones, the plastic pebbles fitting on the solid ones like a cap on the human head. "We find," he says, "among the distorted pebbles cases of this nature. Some pebbles have been more plastic than others, and the results are: indentations of the harder into the softer ones, curves around the hard ones, or the fitting of one into another like a ball into its socket, or the ends of the elongated pebbles may only fit upon each other to economize space"—as in the woodcut.

An example of the first stage of the distortion of pebbles is to be seen near Newport, R.I. The lower carboniferous conglomerate at Alms House, north of that city, is in a normal state, and consists of a mass of loosely-cemented cobble-stones, from an inch to six inches in diameter, all round or spheroidal; but two miles further, at Purgatory, there is another mass of conglomerate, nearly of the same age, having the pebbles much elongated in the direction of the strike, flattened, and often indented, "by being pressed one into the other;" they are sometimes a good deal bent, occasionally in two directions, the whole being cut across by parallel joints or fissures, varying in distance from one or two inches to many feet. The cement is very meagre, and consists of talcose schist, containing crystals of magnetite: the pebbles, however, are firmly adherent. In small flexures of the strata, Dr. Hitchcock has observed the elongated pebbles bent at the same angles.

The part of the 'Philosophical Transactions of the Royal Society,'* containing Professor Owen's valuable and admirable Report on the extraordinary bird-remains from the lithographic limestone of Pappenheim—the *Archæopteryx macrorus*—has been published during the past month, and the full particulars of the memorable description which excited such attention at Burlington House, in the November of last year, are now before the world. It appears to have received little alteration or emendation, as far as our memory will permit our judging, since the time of its first reading, when the completeness and lucidness of the account were features which prominently struck all hearers. The first evidence of bird-remains in the Solenhofen-beds was, as it is well known, the impression of a single feather, described and figured, with his characteristic minuteness and care, by Hermann von Mayer, in the 'Jahrbuch für Mineralogie,' under the title of *Archæopteryx lithographica*, and although it is most probable that the class of birds was represented in the Solenhofen age by more than one family, Professor Owen has retained the generic appellation of Archæopteryx for the present specimen. As the reptilian pterodactyles of the lithographic stone differ in the length of their tails—some having extremely long ones, as the *Ramphorhynchus longicaudus*, and others scarcely any, as the *Pterodactylus crassirostris*, so we may expect to find similar differences in the strange birds which lived in those days; and just as the original appellation of Griphosaurus given to it by Wagner, under the idea of its being a feathered reptile, has been changed to Archæopteryx, it is not by any means certain that the generic term may not yet have to be again altered.

Professor Owen's paper commences with an account of the circumstances under which the specimen was found and those under which it was acquired for our national collection. The exposed bones in the specimen are then named, and one after another compared with those of recent birds of different species, and the corresponding bones of various fossil pterodactyles, a comparison requiring unusual care and accuracy on account of the previously supposed reptilian characters of the singular remains. By his examination and comparison Professor Owen has proved the general ornithic nature of the fossil—a conclusion which must be henceforth adopted; although there are some points which cannot be settled by the present relics, and which may hereafter, when fresh examples revive the subject, give rise to some important considerations. A magnificent lithograph of natural size is given of the principal slab and its contents, even to its ripples and surface-markings, by Mr. Dinkel, who has as conscientiously done his duty in

* 'Philosophical Transactions of the Royal Society of London,' vol. cliii. part 1, 1863.

as faithful a representation as it is in an artist's power to attain. But neither Mr. Dinkel nor any other artist can free himself from a bias of ideas. The hand will follow the mind, and given the notion of a fish's head, the pencil will involuntarily portray the resemblance in figuring the object to which the resemblance is assigned. When Professor Owen first described the Pappenheim specimen, he made no mention of what has since been described by Mr. Mackie as the brain or cast of the cerebral cavity of the skull, nor of certain osseous relics which in the present publication are referred to as a "premaxillary bone, and its impression resembling that of a fossil fish." And yet these objects are perhaps among, if not actually, the most important of all the fossilized remains. The nodule representing the brain, it is admitted by the Professor, may be, as suggested by Mr. Evans, "part of the cranium with the cast of the brain of the Archæopteryx;" but of the so-called fish-head he makes no other remark than the quotation above, "resembling that of a fossil fish." Nor do we blame his reticence. Every word Professor Owen says carries weight, and the last-mentioned object is certainly in so obscure a state that no one, without further illustrative fossils, could by any possibility determine what it is. It would be discordant with all our present knowledge to find a bird's beak containing teeth in sockets, yet that would not be more extraordinary nor more out of all comparisons with living things than a long tail such as the Archæopteryx undoubtedly possesses. Yet such a toothed bill may be possible. After many days' careful study and comparison we could not convince ourselves that this object was a fish's jaw, nor could we find evidence enough to assert that it was a bird's beak with teeth; but it certainly has, as it lies in the slab, as much likeness to a beak as to a premaxillary, and as there is not a fish-scale nor a fish-bone in the whole slab, nor in its counterpart, nor a speck nor portion of a fish in either, it is as possible for this object to belong to the Archæopteryx as to any other creature.

The general ornithic nature of the fossil is, as we have already said, indisputable, but not so positive do we think can anyone be as to its exceptional characters. If the Archæopteryx had in its long vertebrate tail, one character so exceptional as not to be matched by any existing or any other fossil bird, it may have had other characters as exceptional; and although we should say that no bird that preened its feathers would have teeth, yet the beak of a bird is but a modified mammalian jaw, just as the whole structure of birds is a modification of the mammalian type; so it is not without the bounds of possibility that a bird's jaw may be in such a state of development as to retain some traces of teeth. Nor can we be certain, it seems to us, that there are no reptilian affinities, or, at least, resemblances in the structure of the wings. Had the manus of Archæopteryx been adapted for the support of a membranous wing, the extent to which the skeleton is preserved, and the ordinary condition of the fossil Pterosauria in the lithographic stone, render it almost certain, as Professor Owen properly observes, that some of these most characteristic long slender bones of the pterosaurian wing-fingers would have been visible if such had existed in the present specimen; and besides this negative evidence, the positive proof of the bird-like proportions of the pinion, and the existence of quill-feathers, sufficiently evince the true class-affinity of the Archæopteryx. We are, however, in ignorance as to the manner in which those singular wing-hooks were attached to the main bones of the wing, and of all the comparisons which Professor Owen has made with the spur-winged birds, such as the *Merula dactyloptera*, *Anser gambensis*, *Parra jacana*, *Palamedea cornuta*, and *Megapodius*, there are none, we believe, which give us a single illustration of the same character of organization as is exhibited by the claw-hooks in the Archæopteryx. Indeed, Professor Owen admits that in this respect, it differs from every known bird in having "two free unguiculate digits," *i. e.* the wing-hooks, "in the hand," and that "these digits in the slenderness of the penultimate phalanx do resemble the unguiculate digits in the hand of the Pterodactyle." But it is true, as Professor Owen continues, that "the claw has not the characteristic depth or breadth of that of the Pterodactyle; and there is no trace of the much lengthened metacarpal and phalangial bones of the fifth digit, or peculiar wing-finger of the flying reptile." We doubt, however, if the wing-claws of the Archæopteryx are comparable with the spurs of the jacana, or of the screamer; and we are not aware that the skeletons of either are obtainable in this country for comparison.

These are questions, however, which it is judicious of the Professor to avoid until there is sufficient evidence collected to warrant, if not a decisive, at least a reliable opinion. It is quite a different thing for us to point them out, that the importance of obtaining further illustrative specimens may be borne in mind.

VI. MICROSCOPICAL SCIENCE.

As the advance of all physical science depends in a great measure on the degree of perfection of the instruments with which it is studied, we propose devoting this, our first article on the progress of Microscopical research, to a brief exposition of the improvements that have been recently made in the construction of the instrument. Our next article, on the other hand, shall be devoted to a review of the modern standard works on the Microscope, and its mode of application; and then having, as it were, set our house in order, we shall be prepared in our subsequent Numbers to enter directly on the true object of our work, namely, to keep our readers *au courant* with the progress of microscopical inquiry.

Fortunately for us, we do not at the present day require to say anything in support of the claims of the microscope to public attention. Scientific men have unanimously decided in its favour, and although, among the general public, there are still individuals to be encountered who regard its teachings with distrust, their number is day by day becoming more and more limited, as the object and powers of the instrument are becoming better and better understood. Many false doctrines have no doubt been promulgated in consequence of the employment of the microscope; but for one that depended on the imperfection of the instrument, a thousand arose from a defect in the observer. We are even forced to admit, that there are still amongst us, men who without any previous training, or special aptitude for microscopical research, damage the cause in which they are volunteers, by insisting upon publishing the result of their labours, and loading our journals with false data and erroneous theories; which although perhaps perfectly harmless in themselves, nevertheless clog the chariot wheels of progress. And what is still more unfortunate, these would-be discoverers often become the worst enemies of the microscope; for, as in the course of time they see their cherished facts and theories one by one swept away, instead of attributing this their misfortune to its proper cause, they seek to turn the blame against the instrument, which they imagine misled them. In a word, the enemies of the microscope, at the present time, are only to be found, either among those who do not possess an instrument, or possessing one, do not know how to use it. Remember, we do not consider that a man knows how to employ the microscope because he can demonstrate the presence of infusoria in a drop of water, exhibit muscular fibres on prepared slides, or focus photographs of the Royal family, not bigger than a pin's point; for nine out of every dozen of men who can do that are unequal to the preparation and demonstration of a piece of simple cellular tissue. If the microscope fails to assist such as we have just been describing, that is no reason why it should fail to assist others, even although they are not scientific men.

The education requisite for microscopical inquiry is a special education, attainable by every ordinarily educated man, either by means of books, or, what is still better, by oral instruction. In proof of this assertion we have only to look around us, and see in whose hands the microscope is now being turned to account, and we shall at once perceive that the employment of the instrument is no longer the monopoly of professional men. It has even passed through the second stage of its career, and after having for a time occupied the place of instructor of the idle hour to the amateur, has entered, in the hands of the commercial class, upon the third phase of its existence. The liquids we drink, the food we eat, the clothes we wear, have each been found to lie within its scope. Hence the microscope is to be met with in the office, in the warehouse, and in the shop. It is consulted in ascertaining the purity of flour, in revealing the nature of arrowroot, in unmasking the adulterations of coffee, and in innumerable other ways advancing the interests of trade. And it would prove even still more useful in its commercial capacity, if men would but refrain from seeking its assistance until they had exhausted the information attainable by the unaided eye; for the true object of the microscope is not to supplant, as too many imagine, but to extend our ordinary means of observation, and when so employed it never fails to yield important information. It is not, of course, to be supposed from these remarks, that we would try to limit its field of usefulness, for our object is, on the contrary, to endeavour to enlarge it. The advice we give has, in fact, this object in view, and is simply that if, instead of directly placing an object under the microscope, the observer will first take the trouble to examine it carefully with the naked eye, he will find himself in a far better position to form a correct judgment of its nature on seeing it under the magnifying-glass, than if he had omitted previously to do so.

Having said this much regarding the observer, we must now turn our attention to his instrument. It is essential that it should be of good quality. When we speak of a microscope being of good quality, we do not mean that it should have handsome and elaborate brass work, for that part which is so attractive to the eye is the least valuable of the whole. 'Tis in the object-glasses—'tis in the lenses, that the real value of the instrument resides, and thus it was that scientific men so long preferred the low-priced insignificant-looking foreign microscopes of Nachet and Oberhauser, to the elaborately got-up English instruments. The foreign opticians sacrificed appearance to utility, while too many of our home manufacturers sacrificed utility to appearance. At the present moment, however, the British manufacturer is inferior to none, even in low-priced instruments, while, as is well known, his superiority in those costing from thirty guineas, and upwards, has never been matter of dispute.

Before speaking of the cheap instruments, we must first call special attention to the high-power object-glasses that have been recently constructed by Messrs. Ross, Powell and Lealand, and Smith, Beck and Beck, the value of which it is scarcely possible to overrate, seeing that there can be no end to discovery, so long as there is no end to instrumental perfection. In our opinion, the only boundary that human knowledge admits of, is that imposed upon it by the limited means of physical observation. Every additional magnifying power is, as it were, a new world gained.

The progress of science, therefore depends as much upon the mechanician, as upon the observer, for the acumen of the latter would fail to reach its goal, if unassisted by the skill of the former.

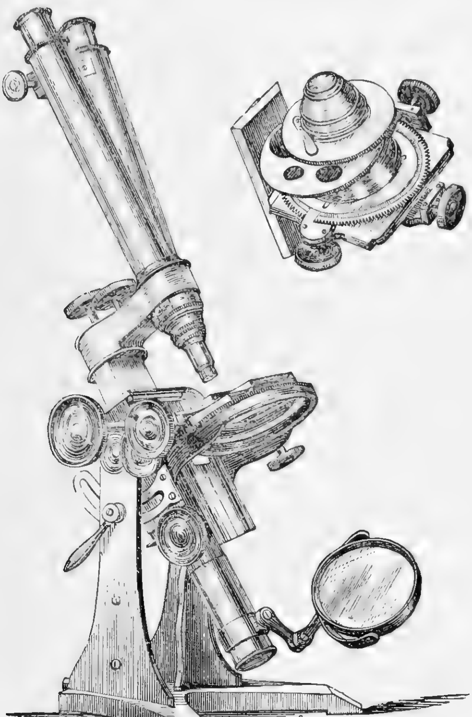
It will be recollected that Ross was the first to succeed in manufacturing an object-glass of $\frac{1}{12}$ of an inch focus, and that shortly afterwards Powell and Lealand overstepped him by producing a $\frac{1}{16}$, which, for the time being, was regarded as quite a scientific curiosity. The latter manufacturers have now, however, stimulated by Professor Beale, outstripped themselves, and actually manufactured a workable lens of no less than $\frac{1}{25}$ of an inch focus. Since then, Ross has improved his $\frac{1}{12}$, and Smith, Beck, and Beck have produced a $\frac{1}{20}$. Perhaps it will be better, if before describing the $\frac{1}{25}$, we first say a few words regarding the $\frac{1}{12}$ of Ross, and the $\frac{1}{20}$ as now supplied by Smith, Beck, and Beck. The advantages of the new $\frac{1}{12}$ are its having a large front distance with a maximum of real angle of aperture. It will work through glass the $\frac{1}{120}$ of an inch thick, and bear the highest eyepieces. These improvements have been accomplished by employing specimens of glass which allow the minimum of thickness of media to be used. The powers with this objective range from 600 to 4,000. The $\frac{1}{20}$ is also so constructed, as to admit a large pencil of light, and at the same time leave a space between its front lens and the covering-glass of the slide sufficient to allow of the examination of ordinary objects. The $\frac{1}{20}$ magnifies with the three eyepieces, 950, 1,700, 3,100, linear; its aperture is 140 degrees; and the thickness of the covering-glass, to which it will adjust, is ·005 of an inch.

The $\frac{1}{25}$ of Messrs. Powell and Lealand, as we already said, was first made at the suggestion of Dr. Beale, and we can corroborate from personal experience the expression made use of by the jurors of the late International Exhibition, namely, that it is possible to see by its means evidences of structure which are under ordinary powers utterly undistinguishable. On looking at an object with the $\frac{1}{25}$, after having first used the $\frac{1}{4}$ of an inch, one is immediately struck with the great difference in size which it presents. The object looks six times as large as it did with the $\frac{1}{4}$ of an inch, and although of course the field is darker, it is not nearly so dark as one might be led to expect, considering that we are employing a magnifying power of 1,300 diameters.

In order to see objects distinctly with the $\frac{1}{25}$, it is, of course, necessary to use a good light; but it does not require that the light should be very much stronger than that ordinarily employed when using a quarter. The common microscope-lamp, and achromatic condenser, are all that is requisite for the purpose of illumination. Like Smith, Beck, and Beck's $\frac{1}{20}$, Powell and Lealand's $\frac{1}{25}$ object-glass is adapted to suit any English microscope, to be used with a covering-glass of ·005 of an inch in thickness, and to leave a sufficient space between the lower lens and the glass to admit of its being employed in the examination of ordinary objects. The $\frac{1}{25}$ consists, like all other good objectives, of eight lenses, two triplets, and one doublet. The front one, indeed, measures only ·025 of an inch in diameter, and to the naked eye looks like a small diamond in its setting. It is, however, a vast deal more valuable than a diamond of the same dimensions.

There is great difficulty experienced in the manufacture of these lenses; for they have actually to be ground under a microscope. This arises not simply because of their small size, but in order to enable the workman to keep the surfaces perfectly level, as a deviation of as little as one thousandth of an inch would give rise to both spherical, and chromatic aberration. To specify the particular class of objects for which the $\frac{1}{25}$ is adapted, is not our present purpose.

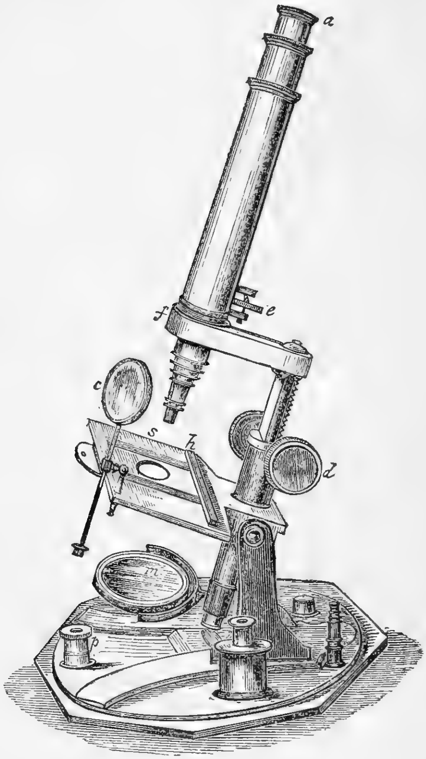
We have now to say a few words regarding the improvements that have recently been introduced into the construction of the large microscope stands. These have for the most part been devised by Mr. Ross, with the view of obtaining additional working room for the illuminating apparatus beneath the stage, in order to acquire the greatest possible angle for simple oblique illumination. This object has been accomplished, as will be seen in the figure, by reducing the thickness of the mechanical and sub-stages. A still further improvement has been made by adding an additional tube, and thereby adapting the instrument to the binocular arrangement. Moreover, Mr. Ross has graduated the circular parts of both the upper and lower stages so as to enable the observer to use the instrument as a goniometer.



We shall now pass on to the consideration of our next head, namely, the diminished cost of instruments for the use of students and others.

At our public institutions where there are large microscopical classes, as, for example, at University College, London, and at the University of Edinburgh, the great majority of the students have hitherto been supplied with the foreign instruments of Nachet and Oberhauser, costing about 8*l*. each. Now, however, English opticians are cutting the ground from beneath the foreigner's feet, by producing really good useful instruments at similar prices. The most recently constructed microscope of the kind, is that just brought out by Parkes of Birmingham.

It is a handsome-looking instrument of the form represented in the accompanying woodcut.



This microscope is made entirely of brass, and is 16 inches high. At first sight, it looks like an instrument costing 18*l.* or 20*l.*, which is more than double the actual price. It is supplied with two powers of a quarter of an inch focus, two eyepieces, a polarising apparatus, a coarse and fine adjustment, a magnetic stage, a circular diaphragm, a double mirror, and a stage condenser.

The microscope is so constructed as to fit into a hexagonal box; the bottom of which forms the stand of the instrument, and into which are set the requisite apparatus. So, no sooner is the top of the box removed, than the microscope is found in its place all ready for use. The objectives and eyepieces are, as we have said, fitted into the stand round the instrument, so that they can be adjusted at a moment's notice, and in order that this may be done more effectively they are fitted with slips as well as screw attachments.

Moreover, the mahogany stand is polished, and has a circular groove round it, to receive the lip of a glass-bell jar, so that the box cover may be dispensed with, except in travelling, and the instrument, with its glass shade, forms a handsome ornament to a room, while at the same time, it is always ready for immediate use.

If Mr. Parkes furnishes a quality of lenses to all his microscopes made on this plan, similar to those attached to the instrument we had the opportunity of seeing at University College, we must admit he will prove a formidable rival to foreign instrument makers.

There are still lower priced instruments, which are extremely well adapted for educational purposes, now being manufactured by Messrs. Highley, Pillischer, Baker, and Smith and Beck; but the consideration of these we must defer to a future occasion, and for the present turn our attention to the binocular microscope.

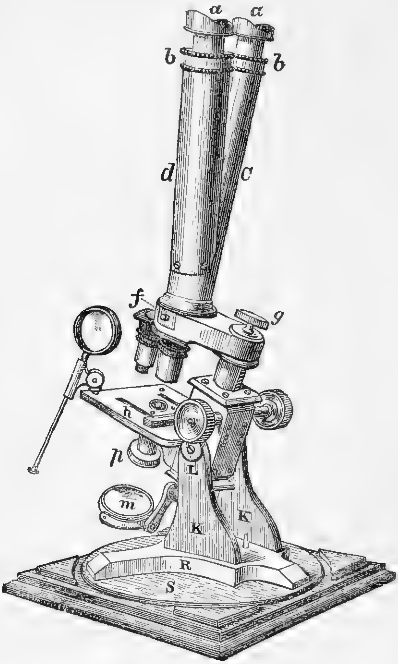
As is well known, the purpose of the binocular microscope is to remedy the difficulty in the way of correct observation, arising from our having to view an object with only one eye. Mr. Wenham, by a very simple contrivance, has accomplished this in a most satisfactory manner, at least, as far as low magnifying powers are concerned; there is still, however, room for improvement with respect to high magnifying powers. By means of a small prism mounted in a brass box which slides into the draw tube immediately over the objective, the rays of light proceeding from the object are reflected in two directions, which by means of a double body are conveyed to both eyes, and thereby give a stereoscopic view of the substance under observation. This is a most important point gained, when uneven surfaces are being examined, because it enables the observer at once to judge of the position, form, and relative distance of the various parts without altering the focus of the microscope.

So valuable, indeed, has this improvement been considered, that all opticians are now prepared to attach an additional draw tube and prism to any of the ordinary uniocular instruments, and thereby make them answer both purposes. For be it remembered, that the attachment of a binocular body in no way interferes with the employment of the instrument as a single-eyed microscope.

As it is impossible, in this short review, to describe all the varieties of binocular microscopes now placed before the public, we must limit our remarks to the one which we consider the most perfect.

The binocular, which we believe is most deserving of this title, is that just brought out by Mr. Collins (of Titchfield Street, Portland Place, London). It is constructed on the model suggested by Professor Harley, and contains all the recent improvements for combining rapidity of application, with simplicity in manipulation. Indeed, so far as the saving of time is concerned, we scarcely know how a change for the better could be devised. It possesses also the further advantage of having the apparatus so arranged as to render it a matter of difficulty to put it out of order. The whole apparatus of the instrument, prism, polariscope, stage condenser, objectives of both high and low powers, &c., &c., are attached to the microscope itself, and that, too, in such a manner as to enable the observer to place them in exact position without the turn of a single screw, or a moment's delay.

A glance at the accompanying woodcut will greatly aid in the understanding of this mode of arrangement.



The microscope, as is here seen, is fixed into the bottom of the mahogany box, which forms at the same time the stand. Round it, like the one previously described, which is in this respect made on Dr. Harley's model, a groove is run to receive the lip of a glass shade. The instrument itself is made of polished brass, and is eighteen inches high. The eyepieces are supplied with shades (*a*, *a*) to protect the eyes.

These are a great comfort to the observer when he is using the instrument for any length of time.

At the end of the transverse arm (*f*), is the box which contains both Wenham's binocular prism, and the analyser of the polariscope; and by merely drawing it a little out, or pushing it farther in, the instrument can be instantly changed from a binocular to a uniocular, and still further to a polarising microscope.

Immediately beneath (*f*) are the two objectives, a quarter, and an inch; so that in order to change the power, all that is necessary is to slide them backwards or forwards. Moreover, these are fitted with the universal screw, so that either of them may be detached, as in an ordinary instrument, and a $\frac{1}{8}$, a $\frac{1}{25}$, or any other power, put in its place at the option of the observer. The instrument is fitted with a coarse and fine adjustment, and has the additional advantage of a magnetic stage, in the cross-bar (*h*) of which is a groove, in order that the observer may enjoy the luxury of applying a Maltwood's finder, as in large instruments possessing movable stages.* Beneath the stage is seen the polariser (*p*), fitted into the circular diaphragm.

The double mirror (*m*) possesses a triple joint, so that it can be applied obliquely in all directions. Indeed, as we before said, it is difficult to see how an instrument could be devised of a more simple, and, at the same time, so perfect construction at the price.

Having now given our readers an insight into the most important improvements that have been recently made in the construction of the instrument, we purpose in our next Number introducing to their notice, the various works on the microscope, and its mode of application.

VII. MINING, MINERALOGY, AND METALLURGY.

The Mining operations of these islands may be regarded as amongst the most important of our industries, taxing—as they do, to the utmost—the powers of man's endurance, and the resources of engineering science; requiring the boldest expenditure of an enormous capital, and adding nearly thirty millions sterling to our national wealth. Hidden in our rocks is the "hoarded treasure," but man, the magician with the wand of industry, brings it forth to-day and converts the valueless ores into valuable metals, which minister in a thousand forms to the necessities of human existence.

The subterranean explorations now in active progress in this country, claim the labours of above 300,000 Miners, independently of men, boys and women, employed at the surface. They task the powers of thousands of steam-engines in pumping the waters from the depths; in drawing the minerals from the mines; in lowering and raising the men; and in restoring pure air to those dark recesses in which the atmosphere is rapidly suffering deterioration from several causes.

At the present time there are upwards of 3,000 collieries, and not less than 1,000 metalliferous mines at work in the United Kingdom. The produce of these—in the more important minerals only—during the last two years, has been as follows:†—

	1861. Tons.	1862. Tons.
Coals	85,635,214	81,638,338
Iron Ore	7,215,518	7,562,240
Copper	231,487	224,171
Tin	11,640	14,127
Lead	90,696	95,311
Zinc	15,770	7,497
Pyrites	125,135	98,433

* Maltwood's finder can be obtained at Smith, Beck, and Beck's.

† These, and all the statistical returns given, are taken from the 'Mineral Statistics of the United Kingdom,' by Robert Hunt, F.R.S., which are published annually by order of the Lords Commissioners of Her Majesty's Treasury.

In addition to these, of ores of the metals, our mines give us Silver, Nickel, Cobalt, Tungsten, Antimony, Manganese, and others. Of earthy minerals we produce Barytes, Strontian, and Gypsum, independently of the Lime, Magnesia, Porcelain, and other clays; while the Salt districts of Cheshire and Worcestershire give us above 900,000 tons of Salt annually.

Gold must be regarded as an unusual product from British rocks, but the Quartz lodes in the vicinity of Dolgelly gave us of that precious metal, in 1861, 2,784 standard ounces, of the value of 10,817*l.*, and in 1862, 5,299 standard ounces, the value of which was 30,390*l.*

Nearly all the Lead ores of these Islands contain Silver, and from this source, by an interesting Metallurgical process, we obtained, in 1861, 569,530 ounces, and in 1862, 686,123 ounces of sterling Silver.

From the returns obtained by the 'Mining Record' Office, we learn that the values of the Metals produced from the ores of the British Islands alone, and Coals, were at the place of production—

In 1861 at 34,602,853*l.*
In 1862 at 34,691,037*l.*

In this rapid sketch, we endeavour to convey a correct idea of the importance of our Mining operations, without loading our pages with details, which may be consulted by all who are interested in the subject, in the publication already quoted.

Directly connected with our Coal-Mining, one question of the highest importance has been recently revived:—that is, the probable duration of our coal-beds. Sir William Armstrong, in his Address as President of the British Association, at the recent Meeting at Newcastle-on-Tyne, spoke as follows on this subject:—"By combining the known thickness of the various workable seams of coal, and computing the area of the surface under which they lie, it is easy to arrive at an estimate of the total quantity comprised in our coal-bearing strata. Assuming 4,000 feet as the greatest depth at which it will ever be possible to carry on mining operations, and rejecting all seams of less than two feet in thickness, the entire available coal existing in these Islands has been calculated to amount to about 80,000 millions of tons, which, at the present rate of consumption, would be exhausted in 930 years; but, with a continued yearly increase of two millions and three quarters of tons, would only last *two hundred and twelve years.*" *

Mr. Greenwell stated a few years since his opinion that "the Northern coal-field would continue 331 years." Mr. T. Y. Hall agrees in the main with Mr. Greenwell, and taking the annual consumption of the Newcastle coal-field at 14 millions of tons, he gives 365 years as the period at which this coal-field will be exhausted. Mr. Fordyce in 1860, supposing the drain upon this coal-field to be 20 millions of tons annually, says, "then at this rate of demand the coal-field would be exhausted in the course of 256 years."†

* Report of the Meeting of the British Association at Newcastle, 1863.

† See 'The Transactions of the North of England Institute of Mining Engineers,' and Fordyce's 'History of Coal, Coke, and Coal Fields,' 1860.

In the Report presented by the Coal Trade at the recent Meeting of the British Association, the rate at which the reporters suppose the exhaustion of this coal-field is going on in 1861, is given at 21,777,570 tons.* This quantity is above that which is given in the 'Mineral Statistics for 1862' (we there find 19,360,356 tons recorded as the quantity raised and sold; but the coal wasted is not reported, owing to the uncertainty of the returns obtained).

Mr. Edward Hull has devoted much attention to this important subject. He calculates that the total remaining supply of coal amounts to 79,843 millions of tons, and "that in the whole of Great Britain the supply is sufficient to last for upwards of a thousand years with a production of 72 millions of tons annually." †

It has been already shown that the general rate of exhaustion has exceeded this computation by twelve millions of tons. It is not, however, probable that there will be any long continuance of such a rapid increase. The progress of civilization has ever been a system of undulations, the maximum of elevation is reached, and the still onward wave subsides, the momentum acquired in its decline being the power by which it again rises to its highest level. Let it not be inferred from this that we suppose our commerce and manufactures to have reached their highest point. It is believed that a large extension is before us, but we argue, from the history of the past, that our progress will not be a system of continuous rise in the future. The question requiring the limits of time within which the coal-fields of these Islands will be exhausted has been hastily propounded, and no less hastily replied to. No satisfactory computation of the quantities of *workable* coal remaining in our several coal-fields has yet been made. Mr. E. Hull, in his work already quoted, has given the best existing information, but those most intimately acquainted with special localities, all alike pronounce the evidence to be incomplete. This is admitted, by the grant of a small sum from the funds of the British Association, to collect exact information on this point. The grant is so small, for the amount of work which is to be done, that nothing satisfactory can be expected from this assistance. The Government having at its command a trained body of men, of superior scientific knowledge, in the officers of the Geological Survey, with twelve Inspectors of Collieries, each man well acquainted with his own district, and a Mining Record office with its statistical returns, might, by a judicious arrangement, and a sufficient grant of money, determine the question within very small limits of error. This stock-taking would be a very important one, bearing as it does, on the future of every manufacturing and commercial industry, which has placed our country the foremost amongst the nations,—a position which we desire to retain. Referring, of course to their own field only, the Reporters on the Northern coal-field say, "Until further and more extensive explora-

* 'On Coal, Coke, and Coal Mining,' by Nicholas Wood, F.G.S., John Taylor, John Marley, and J. W. Pease, in 'History of the Trade and Manufactures of the Tyne, Wear, and Tees.' Spon: London, 1863.

† 'The Coal Fields of Great Britain,' by Edward Hull, B.A. Second edition. Stanford: London.

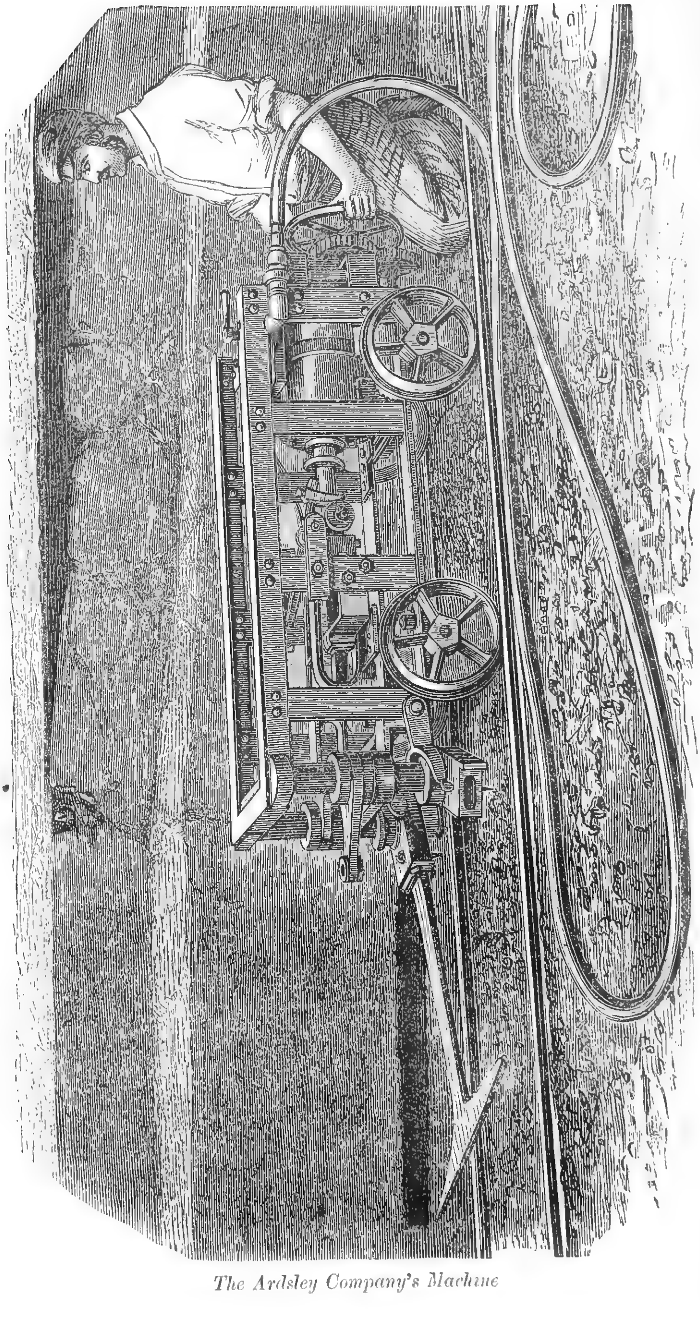
tions determine at what distance beyond the coast the greatest depression of the coal-beds will be found, we are completely at fault as to the quantity of coal lying underneath the sea. * * * * We have not yet reached the threshold of such a conjecture. We have not yet explored one square mile of this vast unknown space, or determined one of the many elements required in such an intricate and uncertain investigation." To a certain extent, these remarks will apply with all their force to other localities. The difficulties determining the existence of coal, and its quantity, under several unexplored regions are exceedingly great, and until opened out, it could only be approximately estimated. Still we cannot but think the concluding remark of the Reporters, that "such an investigation can be of no practical utility, and that the attempt for a vast period of time is, at the least, premature," is one induced, rather by the influences of commerce, looking only to the present, than by the broader spirit of philanthropy which embraces the future. It may not be out of place here to caution the less scientific of our readers from receiving, as in any way probable, that speculation which is echoed from book to book promising man that science will find, when coal is exhausted, some other source of heat and light, which shall be equally economical and as easy of application. If those speculative minds, who suppose the time will come when the constituents of water will be burnt, or electricity be made an unfailing producer of heat, would but carefully entertain the fact, that every form of physical force is the result of the destruction (*change of form*) of matter somewhere, they would be more cautious in promulgating their unsupported hypotheses. To burn zinc or iron in a voltaic battery to produce heat or light, must always be infinitely more costly than burning coal in a furnace.

The lamentable catastrophes which from time to time occur in our collieries, awaken public attention, and excite the utmost sympathy for the sorrowing survivors. That there is a deep-felt desire to assuage the flood of misery which falls, tempest-like, upon a colliery village; and so far to improve the conditions under which the coal-miner labours, as to render the risks less imminent to him, is proved by the manner in which money was poured into the Hartley Fund. After some delay, the large sum which remained unexpended, after every necessary want had been satisfied amongst the widows and orphans of those poor men who perished so miserably in that Colliery, has been distributed to other districts for the purpose of forming the nucleus of local funds to meet such exigencies as may unhappily arise. The public expression of feeling is loud, it will be heard and attended to; but, independently of the impulse which is due to this voice, it must not be forgotten that numerous minds are, and have been silently and earnestly at work, aiming to improve all the conditions of our collieries, and so to render accidents less common.

We have lately, at the Morfa Colliery, in South Wales, had an explosion of fire-damp, by which 39 men were destroyed. This serious accident occurred in a colliery remarkable for its very excellent arrangements. The works were carried on under the most skilled colliery engineers; the ventilation was excellent; locked safety-lamps were always used; and the strictness with which a well-devised code of rules was enforced appeared to secure this colliery from accident by explosion. Yet, when least expected, the fire-damp accumulates, and mysteriously it is fired, sweeping away in a moment 39 men, and strewing wreck around in its deadly progress. This sad accident should teach us that we must not suppose we can, by any skill or care, secure absolute immunity from casualties of this class. In all probability the Morfa explosion arose from a sudden outburst of carburetted hydrogen gas, attended with a fall of the roof, by which the wire gauze of a safety-lamp became broken. It is important that a record should be prominently made of the fact, that the proprietors of this colliery, the Messrs. Vivian, refused the aid which the public readily offered, and that they take upon themselves the burthen of supporting the widows and orphans of those who perished in their employment. Knowing the imperfections of human nature, and the power exerted by selfishness over the better feelings of the heart, we are persuaded that both master and man would be permanently benefited by a legislative enactment, rendering it imperative that the Colliery proprietor should be responsible for the maintenance of the widow and the child of the collier, who has perished by accident in his pit. With such a provision, a more searching system of inspection would be introduced; the workings would be kept in better order; rules would be more rigidly enforced; and, as a consequence, the coal would be obtained in better condition, and at less cost, than at present. Beyond this, the Colliery proprietors would speedily protect themselves by forming funds to meet the exigencies as they arose. A course of this kind is the only one left for trial: there is surely philanthropy enough in this Christian land to force on the experiment.

In nearly every division of human labour, some mechanical power has been introduced for the purpose of relieving the labourer from the constant strain made upon his muscular system. The coal-hewer has not, however, been in any way assisted. With the primitive pick and the ancient wedge, he has been compelled, often under the most trying conditions, to "get" the coal. This state of things may be accounted for by the circumstance that Mining work is performed in the deep and dark bowels of the earth, where there is little to attract, and much to repel, such minds as usually give birth to appliances of physical force. The subject has not been, however, entirely neglected. So long since as 1789, a patent appears to have been granted for improved machinery to be used in getting coal, and since that time many plans have been proposed, and some of them patented, though none have been successfully applied. The first machine which has been found capable of taking its place in the regular business of coal-cutting is one belonging to the West Ardsley Coal Company, Messrs. Firth, Donisthorpe, and Bower. This machine has been in regular work during the last twelve months, and it appears to be admirably adapted to the purpose for which it is contrived.

The Machine—shown on the adjoining plate—is carried on a cast-metal frame of great firmness, the size and weight varying to suit the condition and thickness of the bed of coal to be operated upon. An



The Ardsley Company's Machine

Engine is mounted within this framework: it is actuated by compressed air, and so arranged as to give the blow of the pick or cutter, either by the *pull* or the *push* of the piston. Almost any form of engine is applicable, but that which is employed with advantage in practice at Ardsley Colliery, is the oscillating cylinder principle, whereby is obtained compactness of form and diminished friction in the working parts. The whole is carried upon wheels with flanges, sometimes single and sometimes double, as may be required by the nature of the work. It is propelled backward and forward by a wheel and screw, or a ratchet and pawl, which is fized on one side. On the other side is the valve-lever to regulate the admission and the emission of the air, and the stroke of the piston when the Machine is at work; the man in charge of it moves the ratchet-lever, which is connected with the gearing of the under-carriage, and thus pushes up the carriage on the tram, a distance equal to the cut of the previous blow; and so moves on to the end of the "bank," or working face of the coal. In seams of three feet, or upwards in thickness, the man may sit on a movable seat fixed at the end of the Machine, but in thin seams this cannot be done, and he has to kneel on a truck running on low pulleys or rollers which travel in the rear of the cutting-machine.

The cut, or groove of the coal, made by hand-labour, is a triangular opening varying in size according to the hardness and nature of the coal, but averaging from 9 to 12 inches. In firm coal the machine makes a cut which is not usually more than 2½ inches' opening, and the under-cut is taken 3 feet into the coal. The Ardsley Coal Company state that the coal is obtained in a better condition by machine, than by hand cutting, so much so that about 1*s.* a ton more can be obtained for the coal, on the yield of the seam.

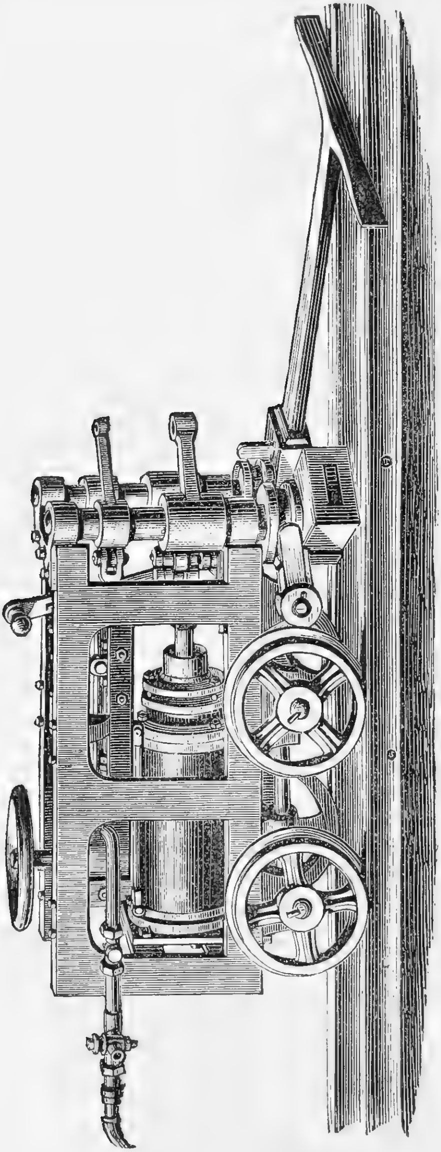
A matter of more importance than this is urged by the proprietors, *viz.* the diminished risk to the persons and lives of the employed.

Numerous lives are lost by falls of coal. It will be well understood, that, if the miner has made an opening in the lower part of the coal, which shall be 12 inches wide on the face, and the superincumbent mass of coal should by its weight fall, much care will be required on the part of the workman to keep himself harmless. Often, when working in a constrained position, the coalhewer, unable to relieve himself from the falling masses, is crushed to death.

By the machine work there is much less liability to this kind of accident. The groove being narrow can be spragged with ease and system, and a slip in the coal only closes up the groove. In ordinary cases the coal is not pushed out; but, if it does come forward, there is little danger to the workman, because he can readily get out of the way, and if it catches the machine but little injury is done. There are some technical advantages, beyond those named, which need not be noticed in this Journal.

The length of the coal-cutting machine which we have described, has been thought by some to be a disadvantage. Difficulties are said to have arisen when it was required to be taken round the short elbows, and the abrupt curves, which often occur in a colliery. To obviate this

Messrs. Ridley and Jones have constructed a new machine, which is about half the length of the machine in use by the Ardsley Company. This diminution in the length is effected by an ingenious arrangement,



Ridley & Jones's Machine.

the connecting rod to which the pick is attached, acting as a substitute for the piston, in this way the required length of stroke is obtained, as it were, within the cylinder itself.

This machine is very small and compact, being two feet two inches high, and three feet long, the pick being two feet six inches in length. As in the former case a man and a boy attend the machine in its progress along the ordinary tramway of the colliery.

The following diagrams will render clear the difference between the two machines. Fig. 1 represents the old patent arrangement: *a* is the cylinder, *b* the piston, *c* the piston rod, *d* the connecting rod, *e* the crank or lever. Fig. 2 represents the new patent trunk arrangement: *a* is the cylinder, *b* the piston, *c* the trunk, *d* the connecting rod, *e* the crank or lever.

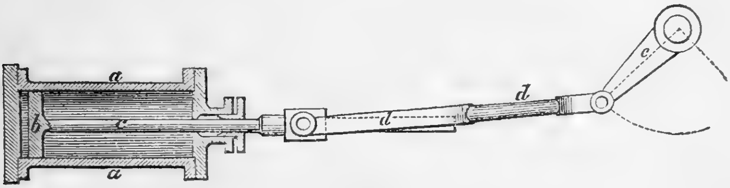


Fig. 1.

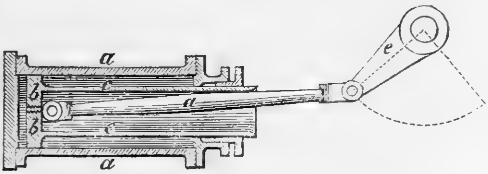


Fig. 2.

Either of these machines is guaranteed to be capable of undercutting a seam of coal to the depth of three feet, and to the length of 150 yards, along the face of the coal, in the space of eight hours. These machines can be worked either by compressed air or by steam. At the Ardsley Pit, air has been employed, and the experience of eighteen months confirms its advantage over any other motive power, for this purpose. The air is pressed into a receiver on the surface, by an ordinary steam-engine, to a pressure of from 45 to 50 lbs. to the inch. It is led down the shaft 80 fathoms deep in $4\frac{1}{2}$-inch metal pipes, and hence in pipes of diminished diameter in the several directions of the workings, and finally into the "Banks" or working faces by India-rubber tubing of $1\frac{1}{4}$-inch diameter.

The use of air, underground, has many advantages. It is free from any kind of danger, and exceedingly manageable; there is nothing of an inconvenient or annoying character to be guarded against. It is clean, dry, pure, and cool.

Beyond all this, when the air has performed its mechanical work, it may be made available for sanatory purposes. When discharged from the cylinder of the coal-cutting machine, under a pressure of three atmospheres, which at 100 strokes per minute, when expanded to its natural volume, gives about 300 cubic feet of air, this supply can be sent into each working face. This air, in expanding, takes heat from all surrounding bodies, thus lowering the temperature of the mine; and it, at the same time, increases the current, and dilutes the noxious agents which are found, as the products of respiration and of combustion, or such as are evolved from the coal itself. The advantages of these machines are most satisfactorily proved, and many coal proprietors have made arrangements for their introduction to their several works.* How will the invention be received by the mining population? is a question which many ask. Since the machine is to relieve the miner from his heaviest labour—to do, indeed, the drudgery of the pit—and thus tend to alleviate his condition, reserving his strength for less injurious trials, he cannot but feel that the aid afforded him is great, and we hope that he will receive it with all thankfulness.

In our anxiety to describe clearly the coal-cutting machines, so much space has been absorbed, that we feel compelled to defer to our next Number all notice of two or three machines—which have been devised, for working upon our hardest rocks,—used in driving levels and proposed for use in sinking shafts in our metalliferous mines.

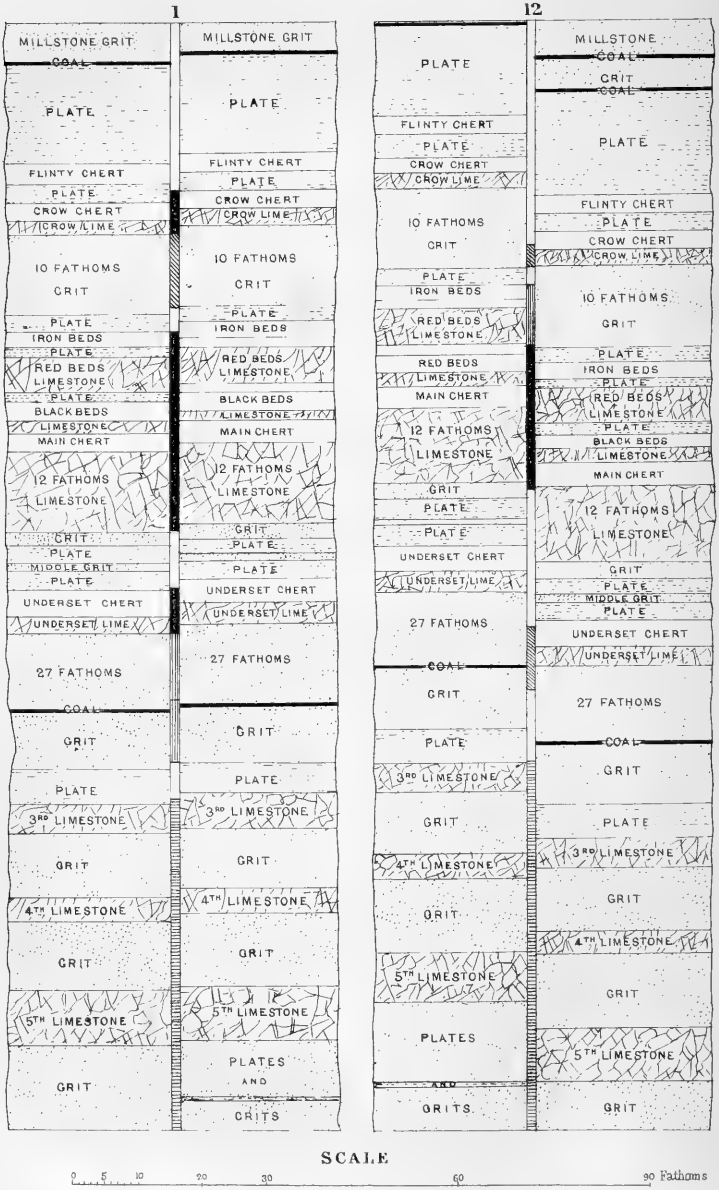
If the collier be exposed to injurious influences—and subject to violent casualties—the metalliferous miner is subjected to conditions so much more distressing, that, although we seldom hear of such dire calamities as those which follow from an explosion of fire-damp, it is too well known that the number who perish young, from the consequences of their labour, is far greater, relatively, than the deaths occurring amongst the coal-miners. Every mechanical aid, therefore, which proves a benefit in one case, becomes a yet greater blessing in the other. We expect before our second Number can appear, that the Report of Lord Kinnaird's Commission, "To inquire into the sanatory conditions of the metalliferous miner," will have been published, and, consequently, it will demand our attention in connection with the boring machinery—analogous to that employed in driving the tunnel through Mont Cenis—which promises to take the wearying task of "beating the borer" from the failing arm of flesh, and transfer it to the resistless arm of iron.

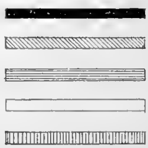
It is interesting to find, that some successful attempts have been made to introduce so much of science amongst our miners as promises to facilitate their labours, and relieve them from the liability to error, which is ever the attendant on ignorance.

The Miners' Association of Cornwall and Devonshire, and the Mining Schools of Bristol, Wigan, and Glasgow, are doing good work. At the same time as those local institutions, supported by limited subscriptions, are earnestly at work, the Royal School of Mines in London, supported by an annual vote from the House of Commons, is providing a numerous staff of young men furnished with all the resources of modern science, to undertake the direction of the ore-

* We believe that the new coal cutting-machine has been at work three months or more at the Ince Hall Colliery.—Ed.

VEINS WITH THROWS
OF ONE AND TWELVE FATHOMS.





Most productive portion of the vein (with or without rider)

Productive in the presence of a rider . . . . . .

Uncertain portions . . . .

Unproductive . . . .

Unexplored . . . .

mines, the engineering difficulties of which are rapidly augmenting with the increasing depth.

The uncertainty which attends the conditions of any of our mineral lodes or veins, is one of the causes which has led to the unfortunate spirit of gambling which marks too many Mining speculations. It may never be possible to pronounce with certainty whether a mineral lode shall prove rich, in the metalliferous ores, in depth. But it is certainly within the limits of human knowledge to be able to pronounce on the high probabilities of any subterranean exploration being remunerative or otherwise.

The Philosopher who stands upon the surface of the Earth, and frames his hypothesis, as to the laws by which the metals have been deposited in the fissures of the rocks, is as likely to run wildly wrong, as the untaught miner, who, without a knowledge of one of the Physical Forces, persuades himself that he has an unfailing rule for determining the value of the hidden treasures. Neither the one nor the other will ever advance knowledge by his guesses. Teach the Miner to observe carefully, and to record his observations correctly—then call in the aid of the Philosopher, and his deductions from a sufficient number of well-observed facts will possess a high value. It is an important and a most favourable feature of the present time, that several practical miners are employed in endeavours to determine if any constant law can be discovered in relation to the accumulation of the Metalliferous ores in lodes.

M. Moisenet, Ingénieur des Mines,—who has himself examined with great industry the Metal Mines of this country,—has endeavoured to refer the conditions of our mineral deposits to actions influenced by the direction of our great mountain ranges. In this country Mr. Lonsdale Bradley has published a valuable set of sections of the strata, in the lead-bearing rocks of Swaledale; and given careful explanations of the actual conditions observed in the veins.

Those sections instruct us on some points, which from their almost constant occurrence, assume the conditions of a law. These are that LIMESTONES and CHERTS are the beds which are productive of lead, and that the GRITS and PLATES are wholly unproductive. All mineral veins must be regarded as lines of dislocation; the strata seldom being precisely similar on both sides of the fissure or lode. Those disturbances are locally termed "throws." The sections published by Mr. L. Bradley appear to prove, amongst other facts, "That veins of simple throws are the most productive of lead-ore from having ore-bearing or ore-producing beds on each side of the veins, opposite or nearly so to each other;" "that veins of large throws are invariably unproductive, because the ore-bearing beds are thrown past each other, and that cross veins of large throws when productive of lead ore are usually so in the Limestones."* In the sections observed in 40 lodes, and given—carefully drawn to scale—in Mr. Bradley's book, these conditions are clearly shown. The accompanying lithographed examples of two kinds of "throw" will fully illustrate this position.

* 'An Inquiry into the Deposition of Lead Ore in the Mineral Veins of Swaledale, Yorkshire.' By Lonsdale Bradley, F.G.S. Edward Stanford, London, 1862.

A far more extensive inquiry has been made by Mr. Wallace of Alston Moor, with a view to the solution of this problem, and he is fully persuaded that, as far as this district is concerned, he has arrived at the true solution.* The balance of evidence is greatly in favour of the hypothesis put forth. It is not possible, within the limits of a summary notice, to explain satisfactorily the views of this writer. Suffice it to say, that Mr. Wallace regards the mineral lodes as channels through which, the waters accumulated on the surface, and percolating the rock, were discharged. These waters are supposed to derive from the adjacent rocks, or from some other source, the minerals which are subsequently deposited in those larger channels. The richness of any lode is determined by several conditions, all of which, however, may be regarded as disturbing causes. For example if, into a main channel of fissure, several lateral fissures flow, it is found that along the main fissure or lode, it is productive of metallic ores at these parts.

Several good examples of this are given in Mr. Wallace's beautifully executed map; one of these we copy. It is a portion of the great Rodderup Fell vein, and shows that the lode is unproductive except where the numerous small lateral veins, as shown in our drawing, have been channels in which fluids have been collected and conveyed to the larger fissure. The vein has proved remarkably productive of

lead in those parts. Mr. Wallace's book is a valuable contribution to the very limited literature which exists in the English language, on mines and mineral deposits. That attention has been awakened to this question, is further proved from the fact, that at the last meeting of the Miners' Association of Cornwall, two Cornish miners contributed papers on the subject.

Such are the matters of interest connected with British Mining, which have recently presented themselves.

As illustrating the value of our mines in relation to those of other countries, it is satisfactory to be able to examine two very recently

* 'The Laws which regulate the Deposition of Lead Ore in Veins: Illustrated by an Examination of the Geological Structure of the Mining Districts of Alston Moor.' By William Wallace. Edward Stanford, London.

published returns, which have been issued by the Governments of Spain and Prussia.

The number of productive mines, in Spain, in 1862, was 1,798, employing 32,789 miners. The results of their labours, and those of the smelter, were as follows :*—

	Minerals.		Metals.
	Tons.		Tons.
Lead Ores . . .	355,756	. . . . .	63,711
Copper „	228,098	. . . . .	2,857
Iron „	128,333	Cast . .	34,022
		Wrought .	32,131
Zinc „	24,378	. . . . .	2,180
Quicksilver Ores .	17,984	. . . . .	923
Silver „ .	2,960	. . . . .	$7\frac{8}{10}$
Tin „ .	1,860	. . . . .	6 [illegible]/10
Coal „ .	326,162	. . . . .	—
Sulphur Ores . .	22,796	. . . . .	4,545
Manganese „ . .	13,863	. . . . .	—

Of the above quantities, the Government mines of Linares produced of lead-ore, 3,521 tons; lead, 2,232 tons; those of Rio Tinto of copper-ore, 79,037 tons, or 1,170 of fine copper; and the important mercury mines of Almaden, 11,191 tons of ore of Cinnabar, yielding of quick-silver, 894 tons. Although Spain produces the largest quantity of lead-ores, its produce of lead falls below that of Great Britain, owing to the poorness of the minerals, their average produce falling below 18 per cent., while the produce of the lead-ores of England averages about 70 per cent.

The Prussian Government has published a valuable set of Mineral and Metallic statistics—being an account of the mineral production of the States for the ten years, 1852—61.† From this it appears that the total value of these products amounted in 1861, to 4,685,000*l.* sterling. The number of mines worked were 2,304, and of workmen employed 115,341. Notwithstanding the insignificance of these returns as compared with the mineral wealth of Britain, it is clear that the production of minerals in Prussia has increased more than six-fold during the past twenty-five years.

The latest returns furnished by the French Government of the production of "Metals other than Iron," show that in twelve departments there existed 23 mines in which were employed 3,072 workmen. The value of the argentiferous lead produced was 1,545,365 francs—and of other metals, 601,623 francs.

There are few sciences which move so slowly as Mineralogy—notwithstanding the Treatises by Dana,‡ by Brooke and Miller,§ and the

* 'Revista Minera.' Madrid, 1st Nov. 1863.

† 'Zusammenstellung der statistischen Ergebnisse des Bergwerks, Hütten- und Salinen-Betriebes in dem Preussischen Staate während der Zehn Jahre von 1852 bis 1861.' Bearbeitet von E. Althaus. 4to. Berlin: 1863.

‡ 'A System of Mineralogy; comprising the most recent Discoveries.' By James D. Dana, A.M.

§ 'An Elementary Introduction to Mineralogy.' By the late William Phillips. New edition, with extensive alterations and additions by H. J. Brooke, F.R.S., F.G.S., and W. H. Miller, M.A., F.R.S., F.G.S.

Glossary by Bristow,* which last will be found one of the most useful of books to the young student in this interesting field, the science of minerals makes no advance. This is referable to the cumbrous, unnatural, and confusing nomenclature which besets it. To call oxide of tin, *Cassiterite*, because it is found in a place which probably was at one time called The Cassiterides,—and to name Copper-glance, or disulphide of copper, *Redruthite*, on the erroneous supposition that the best specimens of this Mineral are found near Redruth, is neither more nor less than absurd. It is hoped that the system of exact nomenclature which has tended so much to advance Chemical science, will ere long be applied to Mineralogy.

There has recently been published in Paris a valuable Manual of Mineralogy,† to which we direct the attention of students. It was, the author informs us, his first intention to have translated the excellent work on this science by Brooke and Miller. He was, however, induced by some considerations, connected chiefly with the optical section of the science, to write a new book, of which the first volume only is published. To those students of Mineralogy who desire to enter earnestly on the study of Crystallography—and the optical characters of crystals—this Manual will be a valuable aid. The completeness with which the localities of the mineral described are given, renders this work an example to some of our English Mineralogists, who have not shown the requisite caution in determining these with exactness. Indeed, by trusting to some of these, M. Des Cloizeaux has occasionally been led astray.

Dr. Wedding, of Bonn, has directed attention to an ore of aluminium occurring at Baux, near Avignon; hence it has been named *Bauxite*. According to Meissionier, it penetrates the chalk as a vein-like mass for a length of nearly two miles. This ore has been mistaken for an iron ore, and employed as such. It consists essentially of alumina and peroxide of iron—which reciprocally replace each other—and water. It contains also small quantities of silicic acid, titanium, and vanadium; some varieties contain about 80 per cent. of alumina, and others almost as much oxide of iron. This ore is applied by MM. Morin and Co. of Nanterre, and Messrs. Bell of Newcastle, to the manufacture of aluminium.

The discovery of rock-salt at Middleton-on-Tees, by Messrs. Bolchow and Vaughan, is of great probable importance. A bed of rock-salt 99 feet in thickness has been pierced by boring at the depth of 1,206 feet from the surface. Mr. Marley's paper on this discovery, which was read at the Newcastle Meeting of the British Association, is about to be published in a revised form by the Institute of Mining Engineers—to this we shall again refer.

Professor N. S. Maskelyne and Dr. Viktor Von Lang, of the British Museum, have contributed some interesting notices of *Aërolites*, which are supposed to have fallen within recent years.‡ These

* 'A Glossary of Mineralogy.' By Henry William Bristow, F.G.S.
† 'Manuel de Minéralogie.' Par A. Des Cloizeaux, Tom. i. Paris: Dunod.
‡ 'Philosophical Magazine,' August, 1863.

notices were commenced in No. 165 of the 'Philosophical Magazine,' by a paper 'on Aërolites,' which included notices of a fall of stones at Butsura, in India, in May, 1861. Their more recent paper contains an account of two other meteorites. One of these stones fell at Khiragurh, 28 miles south-east of Bhurtpoor, on the 28th March, 1860. Another—of which a more detailed account is given—fell on the 16th August, 1843, at Manegaum, in the collectorate of Khandeish, in India.

Of the Manegaum stone, some fragments, amounting only to 2½ ounces, have been preserved in the collection of the Asiatic Society of Bengal, at Calcutta,* and a specimen is deposited in the British Museum. The evidence of the fall of this stone is given in the following words:—

"Two villagers described the fall as having been witnessed by them. There had been several claps of thunder with lightning some two hours previously, and the northern heavens were heavily charged with clouds; but no rain had fallen for eight days before, nor did any fall for four days after, the event. Their attention was arrested by 'several heavy claps of thunder and lightning,' and they ran out of a shed to look around, when they saw the aërolite fall in a slanting direction from north to south 'preceded by a flash of lightning.' It buried itself 5 inches in the ground, and appeared as a mass of about 15 inches long, and 5 inches diameter. It exhibited a black vitreous exterior, and was of a greyish yellow inside. At first, the observers stated it to have been (as is recorded of the Bokkeveldt aërolite) comparatively plastic, and at any rate to have become more hard and compact subsequently. There was only one stone seen, and that was smashed to pieces. Another witness mentioned that the stone was at first cool, but in a short time became rather warm." The evidence which is being accumulated by Shepard, Haidinger, and others, added to the chemical and physical examinations to which these aërolites have been subjected, by Rose, Maskelyne, and Lang, is advancing our knowledge of the peculiarities which belong to those remarkable bodies. The chemical constitution and the lithological characteristics of a peculiar class of stones, appear to prove their meteoric origin. It must, at the same time, be evident to all, that the utmost caution is necessary in examining all the evidence brought forward as descriptive of the phenomena accompanying the fall of stones through the atmosphere—and that, especially, which has led to the assumption that certain physical and chemical peculiarities are characteristic of, and unmistakably indicate, a true meteoric origin.

Dr. C. T. Jackson, of Boston, U.S., gives us some interesting particulars of a mass of Meteoric Iron from the Dakota Indian territory. It was found on the surface of the ground, 90 miles from any road or dwelling, and from its presenting a bright surface when cut, it was thought to be silver. A portion of about 10 lbs. weight was broken from the original mass, which weighed about 100 lbs. This

* 'Proceedings of the Asiatic Society of Bengal' for 1844 contains the first account of this aërolite.

was subjected to analysis, and its meteoric character supposed to be determined. The constituents of the Aërolite were—

Metallic Iron	91·735
„ Nickel	6·532
Tin	0 063
Phosphorus	0·010

Cobalt and chrome were also detected.*

We have already given the value of the Metallurgical products of British ores ; there is little of novelty in the furnace operations to which they are subjected. Although numerous patents have been completed, and notices of many more given, for improvements in the processes of smelting the several metallic ores, there is scarcely anything of sufficient importance to require special notice. One Patent for "separating Silver and other Metals from Lead," founded on a principle discovered by M. Clement Roswag, Engineer, of Paris, promises to be successful.

In carrying out this invention, the first operation consists in fusing the lead containing silver and incorporating zinc therewith. For this purpose a suitable furnace is provided with a melting-pot or vessel, in which the lead and zinc are melted, the zinc being placed in suitable tubes or holders, and deposited, after the lead is melted, at the bottom of the vessel, so that as it melts it rises up through the molten lead by reason of its less specific gravity, and by means of agitators it is uniformly distributed in its passage through the fluid lead. When the whole of the zinc is melted and has risen to the surface of the molten lead, the zinc holders and the agitators are removed from the vessel, and the alloy of zinc and silver is skimmed off the surface, to be operated upon in the ordinary manner by oxidation. The molten lead, which now contains a small percentage of zinc, is next run off into the hollow of a reverberatory furnace, such as is generally used for annealing and refining lead, and the zincy lead is purified by keeping it in a state of fusion at a dull red heat, and subjecting it to the action of the vapours or gases arising from the burning or decomposition of pieces of green wood enclosed in suitable tubes or holders below the surface of the molten lead ; the dross of the zinc (called seconds) is skimmed off during the process, and is added to the alloy of zinc and silver previously obtained. The lead thus refined is run into ingots for sale or use.

Under the name of *Wasium*, a new Metal has been recently announced by M. Bahr, as existing in the Orthite of Norway. M. Nicklès denies the reality of the discovery—according to him, the supposed new simple body is but impure Yttrium.

We expected to have examined Dr. Percy's second volume of Metallurgy, which will be devoted to Iron and Steel ; although long since announced, it is not yet ready for publication. We may, however, safely predict that this work will be a valuable contribution to the Metallurgy of iron.

The late Exhibition furnished many striking illustrations of the importance of mechanical improvements to the worker in Metals.

* 'The American Journal of Science and Arts.' Conducted by Professor B. Silliman and others. No. 107, September, 1863.

This has been most strikingly shown in the application of mechanical engineering to several branches of iron manufacture.

There are few things which illustrate the giant power of machinery more entirely than the manufacture of armour-plates. A number of scientific men, and some of the Lords of the Admiralty, witnessed recently a great experiment with some new Rolling Mills belonging to John Brown of Sheffield. These rolls have a first foundation of no less than 60 tons of solid iron, resting on masonry carried far below the earth. The rollers themselves are 32 inches in diameter, and 8 feet wide, and are turned by an engine of 400-horse power. A powerful screw, applying its force through compound levers, allows the distance between the rollers to be adjusted to the fraction of an inch, so that the plate which on its first rolling, is forced through an interval of—for instance—12 inches apart is, on its next, wound through one of ten inches, next through one of 8 inches, and so on until the required thickness has been carefully and equally attained by compression through every part of the metal. When the enormous mass of iron to be rolled was first taken from the heating furnace, and brought to the rollers, it was found that they did not bite directly the mass came to them, and when they did, the engine was almost brought to a stand-still by the tremendous strain upon it; but at last the soft plate yielded, and the rollers wound it slowly in, squeezing out jets of melted iron, that shot about as the pile was compressed from 19 inches to 17 inches by the force of the rollers. From the time the mass had once passed through the mill, it was kept rolling backwards and forwards, the workmen sweeping from its face the scales of oxide that gathered fast upon it. Every time the plate was passed through, the rollers were squeezed closer and closer together, until at the end of a quarter of an hour from leaving the furnace, an almost melted mass, it was passed through the rolls for the last time, and came out a finished armour-plate, weighing 20 tons, 19 feet long, nearly 4 feet wide, and exactly 12 inches thick throughout from end to end.

Attention has been directed by Lieut-Colonel H. Clerk, R.A., to a matter of some engineering importance, "The Change of Form assumed by Wrought Iron and other Metals when Heated and then Cooled by partial Immersion in Water." The experiments recorded in a communication made by Colonel Clerk to the Royal Society originated in this way:—

"A short time ago, when about to shoe a wheel with a hoop tire, to which it was necessary to give a bevel of about $\frac{3}{8}$th of an inch, one of the workmen suggested that the bevel could be given by heating the tire red hot, and then immersing it one-half its depth in cold water. This was tried and found to answer perfectly, that portion of the tire which was *out of the water* being reduced in diameter." These experiments have an important bearing on many engineering problems; the general result appears to prove that metals heated to redness, and partially cooled, by having one portion only placed in cold water, contract about one inch above the water line, and that this is the same, whether the metal be immersed one-half or two thirds of its depth.

VIII. PHOTOGRAPHY.

By far the most important subject which has arisen in this branch during the last quarter, or, indeed, for many years past, is the alleged discovery of photographs taken half a century before the recognized birth of this art. An immense mass of evidence, direct and collateral, has been collected together in the most conscientious and energetic manner by Mr. Smith, Curator of the Patent Museum, and it certainly affords strong grounds for the presumption that no less than three, if not four, distinct classes of pictures, each by a different process, produced about the year 1790, are now in existence, there being the strongest circumstantial evidence that they are *bonâ fide* photographs. One is on a silver plate, pronounced by leading members of the Photographic Society to be an undoubted photograph from nature, the subject being Mr. Boulton's house, which was pulled down in 1791; the picture was found amongst papers in Mr. Boulton's library, which had not been disturbed during the present century. There are also two pictures—one of them undeniably a photograph—which were found by Miss Meteyard amongst papers supplied to her for the purpose of writing a life of Wedgwood, the great potter; and from documents of that date they are said to have been produced by the younger Wedgwood, reference being made to a lens, camera, and chemicals. There is also the hearsay evidence of an old retainer of the Boulton family, lately dead, of the silver picture of Mr. Boulton's house having been taken by placing a camera on the lawn; and there was a society called the 'Lunar Society,' the members of which were said to produce pictures by using a dark room, throwing the images on to a table, and fixing them by some chemical. The whole subject has recently been brought before the Photographic Society, and, on a careful analysis of the evidence, there is the very strongest presumption, short of absolute certainty, that this important discovery was made, and then suffered to die out. Only a few links in the chain are wanting to establish the actual proof, and from the intense excitement the subject has now occasioned, there is little doubt that it will be sifted to the bottom.

The measurement of the chemical action of light has lately received considerable attention. Dr. Phipson * has published a process which appears to promise very good results; it is based upon the fact, that a solution of sulphate of molybdic acid is reduced by the action of light to a lower state of oxidation; and by measuring this amount of reduction by chemical means, a correct estimate of the amount of actinism used up in the operation is obtained. The measurement is done with a standard solution of permanganate of potash; and Dr. Phipson states that his observations have disclosed the fact, that the amount of actinism during the day varies considerably, describing curves, which are not only irregular, but sometimes present sudden deflections of considerable extent. This phenomenon has been noticed before. During the last summer many correspondents of the 'Photographic

* 'Chemical News,' vol. viii. p. 135.

News' have stated that, on certain days during particular hours, there seemed to be an almost total absence of actinic force. In some instances five and six times the ordinary exposure were given with very imperfect results; and in other instances twenty times were tried with no effect. No particular atmospheric influence could be detected at work; and on subsequent days, apparently identical in light and clearness, photographic operations were conducted with their usual celerity. The cause of this great variation appears to have some connection with the dryness of the atmosphere, the days on which the absence of actinism was most marked having been intensely hot and free from humidity. It is much to be desired that a simple system of actinometry should come into general use. The processes of Draper, Niepce de St. Victor, Bunsen and Roscoe, Herschel, Phipson, and others, are very useful, but rather too tedious for general use. What we want is some method of reading off the amount of actinism as simply as we read off the amount of heat with the thermometer.

A most elaborate series of researches on the behaviour of chloride, bromide, and iodide of silver in the light, and on the theory of photography, has recently been published by M. H. Vogel.* The researches have extended over three years, and are of the most exhaustive character. We have only space to give some of the bare results which he has obtained, and must refer our readers for further particulars to the original memoir. The author considers that the action of light upon chloride and bromide of silver is first the production of a subchloride and subbromide, with liberation of chlorine and bromine, but that the iodide of silver undergoes no chemical change whatever. The action of acids and various saline solutions, especially nitrate of silver, has been studied very carefully, and some of the results are of considerable value. The effect of developing agents has been likewise examined, and the whole memoir constitutes one of the most important contributions to the science of photography ever published.

A valuable improvement has been inaugurated in the manufacture of lenses for photographic purposes. By the ordinary method of grinding and polishing, the surface is not left in a state of perfection anything approaching that required for astronomical glasses. For the usual photographic processes this surface is quite good enough, although, when carefully examined with a powerful glass, it will be seen covered with irregularities, the remains of the last stages of the grinding process. To attain greater perfection entirely different means have to be employed, and the costly nature of this operation is one reason why telescopic lenses are so valuable. For some purposes, however, in which it is absolutely necessary to get perfect delineation, as in the copying maps, &c., a lens ground in the ordinary way would be inapplicable, and perfection must not be hoped for unless the lens possesses a perfectly continuous spherical surface with the highest possible polish. Mr. Osborn, the photographer to the Melbourne Government, who is engaged in copying maps for the Melbourne Survey Office, has just ordered a lens from Mr. Dallmeyer, the cost of which is to be

* Poggendorf's 'Annalen,' 1863, p. 497.

250*l*. It will be a triple achromatic, and the glasses will probably require months for their completion, during the whole of which time the grinding and polishing machinery will have to be moving under the personal superintendence of one of the first practical opticians in England. The experiment is necessarily a costly one, and photographers are naturally anxious to see if the result compensates for the enormous additional expense. The Melbourne Government deserve the thanks of all photographers for the spirit of enterprise they have shown in the matter.

From time to time rock crystal lenses have been recommended on account of their superior transparency to the chemical rays of light. Mr. Grubb has put this theory to the test of experience, and finds that the difference is not so great as has been imagined; for instance, a compound lens of the ordinary make transmits 87 for every 100 rays which the rock crystal allows to pass. It is therefore only 13 per cent. worse, whilst in flatness of field and achromatism, the glass lens is much superior.

M. Gaudin suggests that lenses should be made from fused rock crystal. The manufacture of these is simply a question of expense, and they might possibly be achromatized by the employment of other suitably transparent minerals.

A new fixing agent, sulpho-cyanide of ammonium, is likely ere long to supersede hyposulphite of soda. The advantages claimed are, permanence of the print, and great facility in the washing operations; but, on the other hand, the expense is likely to be an objection. A little time ago, the new agent cost 4*s*. an ounce; there are rumours that it can now be procured in Paris for 1*s*. 1½*d*. per lb., although we have been quite unable to obtain any at this price, and Mr. Spence, the manufacturing chemist of Manchester, has just erected large apparatus, by means of which he hopes to supply the sulpho-cyanide at even a less price. We may therefore reasonably anticipate that sulphur toning, yellow whites, and fading positives, will soon have gone the way of the Dodo and Megatherium.

Celestial photography is making great strides on the other side of the Atlantic. Dr. Henry Draper has just completed a large reflecting telescope, 16 inches in aperture, and 13 feet focus, which he intends to devote to this branch of science. The mirror is of glass, covered at Sir John Herschel's suggestion, with a film of precipitated silver. It is sustained in a walnut tube, hooked with brass, and specially mounted to avoid tremor. When in use the instrument is allowed to be at rest, clockwork being used only to drive the sensitive plate. By this means, only 1 oz. instead of half a ton, is moved. A photographic laboratory is attached to the observatory, and the apparatus is arranged to take photographs of the moon as large as 3 feet in diameter, being on a scale of less than 50 miles to the inch. From the reputation which Dr. Draper has already earned as a photographer and physical philosopher, we are justified in expecting that celestial photography will advance rapidly in his hands.

IX. PHYSICS.

Light, Heat, and Electricity.

Light.—The cause of the scintillations of stars has long been a puzzle, not only to children, but to philosophers. Many explanations have been given, but none are quite satisfactory. Mr. A. Claudet * has thrown some new light upon this subject, by an instrument which he has devised, called the chromatoscope. He attributes the beautiful sparkling, with changing colours, exhibited by certain stars on a clear night, to the evolution in different degrees of swiftness of the various coloured rays they emit. These rays are supposed to divide during their long and rapid course through space, and we see them following each other in quick succession, but so rapidly that, although we see distinctly the various colours, we cannot judge of the separate lengths of their duration. Mr. Claudet's instrument consists of a reflecting telescope, part of which is caused to rotate eccentrically in such a manner, that instead of a point a *ring-like* image of the star is seen. The rapidity of rotation is adjusted so that each separate colour given by the star is drawn out into a large segment of the ring, and in that manner the light from the star can be analysed as in a spectroscope.

In observing the rays of sunlight through a powerful spectroscope many additional lines are visible when the sun is near the horizon. These are called telluric rays, as they have been shown to owe their existence to some components of the earth's atmosphere. Father Secchi, the Roman Astronomer, considers that aqueous vapour in the atmosphere is the principal cause of these telluric rays, and this opinion has been generally adopted by physicists: but M. Volpicelli † now describes experiments to prove that these rays are independent of the presence or absence of aqueous vapour in the atmosphere. In our opinion his experiments are scarcely conclusive; for it is quite reasonable to suppose that the passage of light through 100 miles of atmosphere might produce effects which could not be imitated in a laboratory experiment.

The determination of the refracting power of various transparent liquids and solids, a matter of considerable practical importance, is usually effected by reference to certain well-known lines in the solar spectrum. It would be much easier to have recourse to the bright spectral lines of coloured flames, which are obtainable with ease at any time, whereas the employment of Fraünhofer's lines is dependent on the weather. For accurate experiments it is necessary to know the length of the waves for the differently coloured rays, and this information has been supplied by Dr. J. Müller,‡ by means of one of Nobert's well-divided glass screens. His results show that the length of wave

* 'Phil. Mag.' No. 175.
† 'Cosmos,' vol. xxiii. p. 430.
‡ Poggendorf's 'Annalen,' vol, cxviii. p. 641.

of the red lithium line is 0·0006733 millimetres. The wave length of the yellow sodium line is 0·0005918 millim; * that of the green thallium line is 0·0005348 millim, whilst that of the blue strontium line is 0·0004631 millim.

Perhaps the most powerful spectroscope in the world has recently been constructed by Professor Cooke. It has nine bisulphide of carbon prisms, which are constructed of cast-iron, with parallel sides of glass, special precautions being taken to remedy the curvature of the glass plate from the hardening of the glue. The nine prisms are almost optically perfect, and the light is bent by them through nearly 360°. By its means Professor Cooke has established the following points:— 1. The lines of the solar spectrum are as innumerable as the stars; at least ten times as many being visible as are shown in Kirchhoff's Chart, with an infinitude of nebulous bands, just on the point of being resolved. No less than nine additional lines are seen enclosed within the fixed line D, one being nebulous and showing signs of resolvability under further increase of power. 2. It proves that the coincidences between the metallic lines of artificial spectra and the corresponding dark lines of the solar spectrum remain perfect under this increase of optical power. The two sodium lines can be spread out so as to allow of the thousandth part of the intermediate space being distinguished, and still their coincidence with the Fraünhofer lines is absolute. 3. Many of the bands of metallic spectra are broad coloured spaces crossed by bright lines; this is especially the case in the calcium, barium, and strontium spectra.

Some reliable experiments on the photometric value of the electric light have been published by Professor W. B. Rogers.† The battery was very powerful, consisting of 250 carbon elements, each having an active zinc surface of 85 square inches. They were grouped in fine battalions of 50 each, and the light was obtained in an apartment where a range of about 50 feet could be obtained for the photometric apparatus. Instead of an ordinary standard light, equivalent to 20 candles, a unit was substituted ten times as great, equal therefore to 200 candles. By a series of experiments with the naked electric light unaided by a reflector, it was found that its intensity was from 52 to 61 times as great as the standard light, making it equal in illuminating power from 10,000 to 12,000 standard sperm candles. With the rays concentrated by a parabolic reflector, its illuminating force had a value equal to several millions of candles all pouring forth their light at the same time. The only previous measurement of the illuminating power of the electric light which we can call to mind is one given by Bunsen. This was taken with a less powerful battery (48 cells), and the photometric equivalent was estimated at 572 candles; giving a proportion of 12 candles to the cell, whilst Professor Rogers' estimate gives the ratio of 40 candles to the cell.

* Fraünhofer's measurement for the dark line D of the solar spectrum gave it a wave length of 0·0005888.

† 'Silliman's Journal,' vol. xxxvi. p. 307.

An improved process for silvering glass for telescopic purposes has been published by M. Martin.* He uses four liquids:—The first being a 10 per cent. solution of nitrate of silver; the second, liquor ammoniæ sp. gr. ·970; the third, a 4 per cent. solution of caustic soda; and the fourth, a 12½ per cent. solution of white sugar, to which he adds a ½ per cent. of nitric acid, and after 20 minutes' ebullition adds 25 parts of alcohol, and water to make up the bulk to 250. The silvering liquid is made by mixing together twelve parts of solution 1; then eight parts of No. 2; next twenty parts of No. 3; then sixty parts of distilled water; and finally, in twenty-four hours' time, ten parts of No. 4. The object to be silvered is then to be immersed in, when it will be immediately covered with a film of reduced silver, which in ten or fifteen minutes' time will be sufficiently thick for use. After having been well washed with distilled water and dried, the surface may be polished with chamois leather and rouge.

During some researches on the compounds of mercury with the organic radicals, Dr. Frankland and Mr. B. Duppa discovered a substance which they call mercuric methide. This body is a transparent colourless liquid, of the specific gravity of 3·069, so heavy, in fact, that dense lead glass floats upon its surface. It has been suggested by Mr. Spiller that this would be an admirable liquid for fluid prisms. At present the only substance suited for this purpose is bisulphide of carbon, which is not half the density, besides being objectionable on account of its offensive odour, its great volatility, and easy ignition. Mercuric methide is superior to bisulphide of carbon in all these respects, and its preparation in quantity would not be attended with any particular difficulty.

A most ingenious application of some well-known facts connected with the reflection of light by prisms, has been brought forward by Mr. Henry Swan, at the meeting of the British Association. He takes two rectangular prisms of flint glass, placed with their widest sides in contact. The two copulæ of a stereoscopic picture are placed in contact with this combination, one being at the back and the other at the side. Upon now viewing this arrangement with the two eyes, the picture at the back is seen only by one eye, whilst the side picture is the only one seen by the other eye, the result being that the picture appears projected into the centre of the block of glass, possessing as much apparent solidity as if it were a model cut in ivory.

Heat.—The relation of radiant heat to aqueous vapour is being thoroughly investigated by Professor Tyndall.† He has found that pure dry air is almost perfectly transparent to heat-rays, but that, on a day of average humidity, the quantity of aqueous vapour diffused in London air produces upwards of sixty times the absorption of the air itself. This fact is of vast importance to meteorological science. Ten per cent. of the entire radiation of heat from the earth is absorbed by

* 'Comptes Rendus,' vol. lvi. p. 1044.
† 'Phil. Mag.' vol. xxvi. p. 30.

the aqueous vapour which exists within 10 feet of the earth's surface on a day of average humidity. Wet weather, saturating the atmosphere with vapour, acts as a warm blanket to the earth, whilst cold frosty weather, by drying the air, allows more heat to radiate from the earth, and produces a still greater degree of cold. The relation which these facts bear to many obscure phenomena of climate is fully discussed by Professor Tyndall in the paper already mentioned.

The destructive energy of hot water in steam-boiler explosions has been made the subject of an investigation by the Astronomer Royal.* As the result of many experiments, he concludes that the destructive energy of one cubic foot of water, at the temperature which produces a pressure of 60 lbs. to the square inch, is equal to that of 1 lb. of gunpowder.

A very sensitive thermometer has been described by Dr. Joule.† It consists of a glass tube, 2 feet long and 4 inches in diameter, divided longitudinally by a blackened pasteboard diaphragm, with spaces of about an inch at the top and bottom. In the top space a bit of magnetized sewing-needle, furnished with a glass index, is suspended by a single filament of silk. The arrangement is similar to that of a bratticed coal-pit shaft, and the slightest excess of temperature of one side over that of the other occasions a circulation of air which ascends on the heated side, and, after passing across the glass index, descends on the other side. As a proof of the extreme sensibility of the instrument, it is able to detect the heat radiated by the moon. A beam of moonlight was admitted through a slit in a shutter, and as the ray passed gradually across the instrument, the index was deflected several degrees, showing that the air in the instrument had been raised a few ten-thousandths of a degree in temperature by the moon's rays.

Many researches on the intensity of the electrical current developed by different thermo-electro pairs have been published by M. Edmond Becquerel; he finds that the best thermo-electric couple is composed of platinum and palladium, the two metals being unaltered by heat, and the intensity of the current increasing regularly with the temperature. This electric pyrometer was compared with graduated air-thermometers, and by this means many high temperatures have been able to be expressed in centigrade degrees. We give a few:—The boiling point of sulphur is 448°; the fusing point of silver is 916°; the fusing point of gold, 1,037°; the fusing point of palladium, between 1,360° and 1,380°; the fusing point of platinum, between 1,460° and 1,480°; the highest temperature of a fragment of magnesia, before the oxy-hydrogen blow-pipe, 1,600°; whilst the limit of temperature of the positive carbon of the voltaic arc is 2,000°.

A convenient gas-furnace for experimental purposes has long been wanted. Many contrivances have been made having for their object the production of a furnace-heat with gas, but they have invariably required an artificial blast of air, thus rendering it necessary for one person to be in attendance, and hard at work, during the whole of the

* British Association, Newcastle Meeting.

† 'Proceedings of the Literary and Philosophical Society of Manchester.'

operation. Mr. Gore* has described a new gas-furnace, which possesses many advantages over those hitherto used. It would be difficult to render its construction intelligible without drawings; but the value of it may be understood when we say that the smallest size will melt half-a-pound of copper or six ounces of cast-iron in less than a quarter of an hour, at a cost of about one halfpenny. The melted substances are perfectly accessible to be manipulated upon for a continuous and lengthened period of time, without contact with impurities or with the atmosphere, and without lowering their temperature sufficiently to cause them to solidify. Moreover, these advantages are secured by means of ordinary coal-gas and atmospheric air, without the use of a bellows or a lofty chimney, or of regenerators or valves requiring frequent attention.

Electricity.—The passage of an electrical discharge through various gases and between electrodes of various metals, gives rise to different luminous phenomena. When this light is examined in the spectroscope, it has been found that each elementary gas or metal possesses certain well-marked characteristic lines, and it has generally been assumed :—1. That each substance has a set of lines peculiar to itself. 2. That those lines are not produced or modified by any molecular agent except heat. 3. That the spectrum of one substance is in nowise modified by the presence of another; in such cases both spectra co-existing independently, and are merely superposed. 4. That electricity does not make matter luminous directly, but only by heating it, so that the electric spectrum differs in nothing from that produced by heat of sufficient intensity. Dr. Robinson has examined these questions in a long and laborious investigation, and the result has been presented to the Royal Society, in a Paper "On the Spectra of Electric Light." The opinion to which his results seem to point, is that the origin of the lines is to be referred to some yet undiscovered relation between matter in general and the transfer of electric action; the *places* of the lines being invariably the same, but their *brightness* being modified according to circumstances.

Since attention has been directed to the enormous variation in electric conducting power, caused by the admixture of even minute quantities of metallic or other impurities in copper, it has become a question of some interest to determine the electric conducting power of all the pure metals. Professor Matthiessen † has continued his researches on this subject, and has lately determined the electrical relations of pure thallium. At the freezing point of water this metal has a conducting power equal to 9·16 (pure silver being 100), and its conducting power decreases between the freezing and boiling point, 31·420 per cent., which is a larger percentage decrement than that obtained for many other pure metals, namely, 29·307 per cent.‡ The conducting power of pure iron was found to be, at 0° C = 16·81, with a percentage decrement for an increase of temperature to 100° C = 38·1. The conducting

* 'Chemical News,' vol. viii. p. 2.
† 'Philosophical Transactions,' 1863.
‡ 'Philosophical Transactions,' Part. I., 1862.

powers of the pure metals given in the following table, shows the places which the above metals take in the series.

	Conducting Power at 0°.
Silver	100·00
Copper	99·95
Gold	77·96
Zinc	29·02
Cadmium	23·72
Cobalt	17·22
Iron	16·81
Nickel	13·11
Tin	12·36
Thallium	9·16
Lead	8 32
Arsenic	4·76
Antimony	4·62
Bismuth	1·245.

It has long been a desideratum amongst electricians to obtain a battery having the constancy of Daniell's without the annoyance attending the use of a porous cell. Two such batteries have been described lately. One is the invention of M. Jacobini, and consists of a glass vessel, in which is placed a cylinder of copper pierced with holes; outside this is a larger cylinder of zinc. The copper cylinder is filled with powdered sulphate of copper, tightly pressed down, and the remainder of the space in the glass vessel is filled with sand, touching the zinc cylinder on both sides. Water is then poured in, so as to saturate both the sand and powdered sulphate of copper, and the arrangement is covered up. Several hours elapse before the electric current begins to develope itself actively. It then increases for a few days, and finally sinks again till its power becomes constant. Father Secchi has had a battery of this kind in use for three months, and reports that it is as efficient as when first constructed.

The other battery is the invention of M. Grenet, and is a modification of the sulphate-of-mercury pile of M. Marie-Davy. At the bottom of a glass jar a quantity of acid sulphate of mercury is placed. A stick of gas-carbon and a cylinder of zinc are supported upright in the jar by means of a cork, which closes the upper part of the vessel; water is then carefully poured in, and the whole is set aside, where it will not be shaken or moved. A wire connected with the carbon forms the positive pole, whilst the zinc forms the negative pole. The water becoming gradually charged with sulphate of mercury, attacks the zinc; the hydrogen which is evolved reduces the mercury on the carbon, and the metal as it accumulates falls down to the bottom of the vessel. If the apparatus is not shaken, there are formed two layers of liquid—the lower one consisting almost entirely of a solution of the mercury salt, whilst the upper layer contains the sulphate of zinc. It is owing to this separation that the porous vessel is able to be dispensed with. The battery is employed of two sizes—the larger one contains 500 grammes of water and 100 grammes of mercury salt; the smaller contains respectively 100 grammes and 30 grammes. They are said to keep in perfect order for six months at a time, without once requiring to be touched.

X. SANATORY SCIENCE.

If we were asked to state what it is that more especially characterizes the scientific Practitioner of Medicine of our own day, we should state it to be the strong desire whereby he is actuated to investigate the conditions which lead to the production of disease, the laws that regulate its propagation, and the means by which its exciting causes may be diminished or altogether destroyed. The modern physician does not waste his energies or burn the midnight lamp in anxious strivings after the philosopher's stone, in vain researches for some subtle elixir or fragrant balsam, with a few drops of which he might hope to charm away disease, to renew the life's blood, and impart to the frail and tottering form of age the vigour and elasticity of youth. Neither does he now rely in his treatment of disease on complicated formulæ, which like the once celebrated Mithridate of the ancients, consisted of some two score ingredients; nor on nauseous and disgusting remedies, which, like the oriental Bezoar stones, or the Album Græcum, were invested with a reputed efficacy proportioned to the repulsiveness of their origin. All this is now changed. A striving after simplicity is the order of the day. The sufficiency of the natural processes of recovery, when aided by a few appropriate remedies, is more widely recognized. The necessity of ensuring an abundant supply of fresh air, of practising social and personal cleanliness, of procuring a moderate yet sufficient quantity of food, and of guarding by precautionary measures against the special risks attendant on the pursuit of certain occupations, is now loudly proclaimed.

The importance of paying due attention to all such wise and simple sanatory regulations, is not only at the present time acceded to by the medical profession and the more intelligent of the general public, but has at length been fully recognized by the Legislature. The admirable reports which, in obedience to the Public Health Act for 1858, have now for a series of years been annually submitted to the Privy Council by their medical officer, Mr. Simon, have contributed in no small degree to the distribution of sound information on many of the causes that lead to the production of diseases, and on the means which ought to be taken to mitigate or prevent them. Of the many reports which have proceeded from his pen, there is none, we think, exceeding in general interest the one published in the autumn of the past year.* It embraces careful inquiries into the efficacy of the present system of public vaccination, and particulars as to the supply and distribution of vaccine lymph; into the diseases which may result from the pursuit of some industrial occupations; into the influences probably exerted by the distress in the cotton-manufacturing districts in the production and spread of typhus and other starvation diseases; on the effect produced on the human body by the consumption of the milk or flesh of diseased animals, and on the best steps for lessening the prevalence of disease amongst our domestic animals. As these subjects

* Fifth Report of the Medical Officer of the Privy Council. London, 1863.

all possess a considerable scientific and practical value, it may not be without interest to examine into some of the leading conclusions to which Mr. Simon has been led in the course of his inquiries.

The existence during the last few years of several wide-spread epidemics of small-pox, in different parts of the country, has caused much public attention to be directed to the working of the various statutes which the Legislature has enacted for the national protection against that disease. Doubts have even been thrown by some on the efficiency of the vaccine matter at present employed. It has been assumed that its protecting powers have been, through long-continued transmission from one individual to another, worn out or greatly impaired, and that a more frequent recourse to the original source from which it was obtained ought to have been resorted to. But on this matter Mr. Simon speaks both decidedly and assuringly. He requested Mr. Robert Ceely, of Aylesbury, "to whom more than to any man, since Jenner, the medical profession of this country is indebted for its knowledge of the natural history of vaccination," to inspect all the sources whence lymph is conveyed to the National Vaccine Establishment; and the result of that inspection has been to assure Mr. Ceely "of the perfectly satisfactory character of the lymph there in use."

Of the workings of the different enactments for ensuring a complete system of vaccination the report is anything but satisfactory—nay, the public defences against small-pox are in a great measure insufficient and delusive. The neglect of local authorities in enforcing vaccination in the workhouses and schools under their control; the imperfection of the arrangements for providing at the public expense thoroughly good vaccination, so that it should be everywhere and gratis within reach of those who may choose to avail themselves of it; and the omission in many cases to give the required notification of such arrangements, even when they may have been provided, have all operated in bringing Mr. Simon to this conclusion. But now that attention has been directed to these cases of neglect in the working of the existing machinery, it is to be hoped that means will be taken to ensure a thorough vaccination of the people, and if needful to compel it. We are slow indeed in this country to enact anything which may seem to impose an unnecessary restriction on personal liberty; but the personal liberty of the individual must always be subordinate to the general good. The welfare of the whole community is so closely connected with this question of compulsory vaccination, that we should not regret to see the day when the production of a vaccination certificate will be as essential to holding any office, to gaining employment, or to obtaining admittance to a school, as an attestation of correct principles and good moral character.

The diseases of animals employed as food by man possess an interest both in a sanatory and economic point of view. The influence which the flesh of diseased animals exercises upon those who may consume it has for some time attracted attention. Many strong representations on this subject have been made by Professor John Gamgee, Principal of the New Veterinary College, Edinburgh, and in

1862 he was requested by Mr. Simon to prepare a special report, which is included in the volume. The result of the very elaborate inquiries which Mr. Gamgee has conducted has been to show that disease has prevailed during the last few years, and still prevails very extensively, amongst horned cattle, sheep, and swine, and that the diseased animals are largely employed as human food. The diseases with which these animals are affected may conveniently be classed under three heads:—1st, Contagious Fevers; 2nd, Anthracic and Anthracoid Disorders; 3rd, Parasites. The chief forms of the contagious fevers are those which are more commonly known as the pleuro-pneumonia, or lung disease, of horned cattle, and the aphthous fever, murrain, or foot and mouth disease, which attacks not only horned cattle but also sheep and swine. Small-pox also sometimes attacks sheep, and not many months ago an outbreak of it excited much alarm in Wiltshire. What influence then will the consumption of the flesh of animals so diseased have upon those consuming it? Repulsive though it may be to our notions to eat the flesh of animals which have died of such disorders, and though we may be inclined on *à priori* grounds to suppose it might generate disease in those who eat it, yet more extended investigations must be made before we can state absolutely what the disorders are which it induces in the human frame.

The anthracic and anthracoid diseases are, it is said, frequently accompanied with peculiar changes, in some respects putrefactive, in the blood; erysipelatious and carbuncular affections also sometimes occur, and the body of the animal may develope in itself a specific morbid poison, which, by inoculation, can be communicated to other animals, and cases have been recorded in which disease and even death in man have followed the use of cooked meat derived from animals suffering from anthrax.

The parasitic diseases of the domestic animals are both numerous and important. The so-called "measles" of the pig is nothing more than the diffusion of a parasite, the cysticercus cellulosæ, through the muscular system of the animal; the "sturdy" of the sheep is due to the development of the cœnurus cerebralis in the brain; the "rot" of sheep to the production of flukes, a species of distoma, in the liver; a form of lung-disease is produced by the development in those organs of different kinds of strongylus;* and the muscular system may be infested by multitudes of a minute microscopic worm, the trichina spiralis. Now, there can be no question that meat affected with one or other of the above parasites may become the source of disease in man. Observations on this head have been so multiplied that this statement may be made in the most positive manner. That most troublesome and annoying of all the worms infesting the human bowel, *viz.* the tapeworm, has been shown by the researches of Von Siebold and Küchenmeister to be derived from eating the flesh of "measly" pork, the cysticercus cellulosæ of the pig becoming developed into the tænia solium of the human bowel: and by the ingestion of the cœnurus cerebralis, another form of tænia, the tænia cœnurus is produced. But perhaps the most curious of all these parasites is the

* A nematoid worm.

trichina spiralis which infests the muscular system. So long as it remains in the muscle, it lies quietly coiled up in a spiral form in a small cyst. But as the recent investigations of Virchow, Leuckart, Zenker, and Turner have shown, when the flesh of an animal containing these worms is swallowed, they become disengaged from their cysts, young worms develope in the interior of the females, and this takes place with such rapidity that in a few days the intestinal mucus becomes packed with multitudes of minute threadlike worms. Then from the intestines they migrate in swarms into the muscular system, and there enclose themselves in cysts possessing the same form as those with which their parents were enveloped. The flesh employed as human food which is most frequently infested by the trichina is that of the pig, and more than one case has now been recorded in which violent symptoms, and even death, have followed the use of the flesh of the trichinatous pigs,* and Professor Leuckart has found that trichina meat retains much of its injurious properties, even after some amount of pickling and smoking. We may learn, then, from these instances, how important it is that animals affected with such parasitic diseases should not only most scrupulously be avoided as articles of human food, but that their flesh should not even be given to other animals.

The great diminution which has taken place in the supply of cotton and the consequent stoppage of the factories of our numerous Lancashire towns, by throwing many thousands of persons out of employment, necessarily excited much anxiety not only as to how money was to be procured for their maintenance, but the best and most economical way in which this money was to be spent. The report that typhus fever was making its appearance in some of the towns also excited attention and alarm, and in obedience to the wishes of the Lords of the Privy Council, Mr. Simon requested Dr. Buchanan and Dr. E. Smith to visit the distressed districts and report upon the local precautions taken to prevent that destitution which breeds disease, and to obtain more exact information with regard to the minute economics of diet. The report of Dr. E. Smith is of a most complete and elaborate nature. He has in it endeavoured to answer two important questions. 1st. What is the minimum allowance of money to purchase sufficient food for the maintenance of health? 2nd. What is the best method of expending that allowance?

He has compiled a large collection of formulæ and dietaries, with the wholesale prices and nutritive values of the articles employed. His estimates are based on the real amount of nutriment which is required by these populations; *viz.* 30,100 grains of carbon, and 1,400 grains of nitrogen, weekly. He suggests that relief should be administered in three ways—in money, cooked food, and uncooked food. From the actual experience of the people, it would appear that single persons now spend weekly 2*s.* 4½*d.* each for food; but in the case of families, where there are young children, the rate of expenditure is

* As these pages are going through the press, we notice a paragraph in the daily public prints, in which it is stated that at Herrstadt, in Prussian Silesia, a large number of persons who had eaten at dinner trichinatous pork, were taken suddenly and seriously ill, and that of these sixteen died.

under 2*s*. This sum of 2*s*., at the present rates of prices for food, appears to be the dividing line between sufficiency and insufficiency, as by an expenditure below that sum, health cannot be maintained. There is also much interesting information on the comparative digestibility of certain foods, and on the influence which they exercise both on the secretions and excretions. This report of Dr. Edward Smith's we look upon as a valuable contribution to the study of dietetics, and one which ought to be carefully perused by all who take an interest in providing economically a due quantity and variety of nutritious food for the poor and destitute.

The effect produced by the pursuit of certain occupations, on the health of the employed, has for some years past excited much attention. The prevalence of phthisis amongst file-makers, the tendency to bronchitic disorders exhibited by coal-miners, the paralytic affections and attacks of colic so frequent amongst workers in lead and its compounds, the diseases of the nervous system which attack looking-glass silverers, watch gilders, and others exposed to mercurial emanations, have long been subjects of discussion, and many ingenious plans, mechanical and otherwise, have been devised for warding off the pernicious effects resulting from the pursuit of such occupations. The increase which has of late years taken place in the industrial applications of phosphorus, and of the compound of arsenic called emerald green, or Scheele's green, and the cases in which injurious, nay fatal, effects have been produced on those employed in their manufacture and use, induced Mr. Simon to request Dr. Bristowe and Dr. Guy to make inquiries and report thereon. From the careful examination which Dr. Bristowe has conducted into the methods employed in lucifer match-making—the chief industrial application of phosphorus,—he concludes that the disease of the jaw-bone, to which match-makers are especially liable, might be altogether avoided if amorphous instead of common phosphorus were employed, and that this form of match would possess the additional advantage of not being spontaneously combustible, and therefore not so liable to cause fires. There are, indeed, certain difficulties in the way of carrying out the application of the amorphous phosphorus. But it is the opinion of Mr. Albright, one of the largest manufacturers of phosphorus, "that if the use of the common form were prohibited, the end would be attained completely in six months, to the satisfaction of the manufacturers and the public advantage."

The recent extensive employment of emerald green in the manufacture of wall papers, coloured ornaments of confectionery, artificial leaves and flowers, green tarlatans for dresses, children's toys, &c., has afforded Dr. Guy abundant material for the preparation of his interesting report. He makes many suggestions as to methods which might be adopted to prevent or diminish the risk of poisoning by this pigment, and we recommend all those who may be connected with the different branches of industry in which this brilliant green is employed, to attend carefully to the conclusions to which he has arrived.

At those two great scientific Congresses, the British Association for the Advancement of Science, and the Social Science Association, which now assemble every autumn in one or other of our large towns, various questions affecting public health were at their last meetings brought before their appropriate sections. To some of the most important of these we will now refer. As was not unnatural, the meeting of the British Association last autumn in Newcastle, the centre of one of our most important coal-producing districts, called forth some interesting papers by Drs. Wilson, White, and B. W. Richardson, on the habits and diseases of the miners, and on means which might be employed for diminishing the evil effects of breathing noxious vapours and gases. An excellent paper by Dr. G. Robinson, on organic effluvia, was also communicated, in which the author showed that those abnormal constituents of the atmosphere which are recognized under that term, may be resolved into four principal groups, *viz.*:—1st. Gases and vapours formed during the decomposition of organic matter. 2nd. Odoriferous particles *sui generis*. 3rd. Volatile organic matters not endowed with vitality. 4th. Living germs. On those last-named constituents of the atmosphere many valuable observations were made by Mr. James Samuelson, whose suggestion that the atmosphere of hospitals should be tested microscopically for living germs, appears to us to be of much importance.

The great Sepoy mutiny, &c., by necessitating a much larger number of European troops to be retained in India for defensive purposes than was formerly required, has compelled the attention of the authorities to the need of greater care in promoting and preserving the health of the soldiers stationed there, both in camp and barracks. Papers on this subject were read before the British Association by Drs. Bird, Stewart, Clark, and Camps, and at the Social Science Association by Miss Nightingale and the Rev. Dawson Burns. From the report of the Royal Commission on the sanatory state of the army in India, it would appear that the death rate amongst the British troops serving in India amounts to no less than 69 per 1,000 per annum. Now taking the strength of the British army in India at 73,000, it follows that such an army would lose somewhat over 5,000 men annually, equal to an entire brigade. And as in unhealthy seasons the death rate rises to double the above amount, we may well ask with Miss Nightingale, "Where are the 10,000 recruits to be found to fill up the gap of a single unhealthy year?" and say with her, "that on the better preservation of the health of our troops—hinges the very important social question, *viz.*—How the British race is to hold possession of India, and to bestow upon its vast population the benefit of her own civilization?" This great mortality is due to two distinct sets of causes, for one of which the authorities are responsible; the other is to be ascribed to the personal habits of the men themselves. The building of barracks in bad situations, the crowding together of a large number of men, the insufficient supply of fresh water, the imperfect ventilation, and the deficient drainage are all causes of disease which are under the control of the Government, and for which it ought to be made responsible.

The excessive use of animal food and ardent spirits are those vices amongst the personal habits of the soldier which call most loudly for correction and reform, and we cannot but think that if proper steps be taken, the mortality arising from them may be largely diminished. Experience has shown that the proper carrying out of sanatory principles in other parts of the globe in which British troops are quartered, has succeeded in effecting great improvements in the health of the men, and we see no reason why the same good result should not follow the application of the same principles in our Indian empire.

We cannot close this brief *résumé* of some of the most important recent contributions to Sanatory Science, without directing attention to the suggestive address on many matters connected with public health, delivered at the Edinburgh meeting of the Social Science Association, to the department over which he presided, by Professor Christison.

In this address Dr. Christison inquires into the mode in which the principal diseases or groups of diseases are influenced by the agents which affect public health. One of the most remarkable facts which he elucidates is the total disappearance of ague which has of late years taken place in Scotland, a country in which at one time it was very common. This disappearance does not indeed seem to be coincident with the drainage and agricultural improvements which have been carried on so energetically there for many years past; for the decline in the disease took place before such improvements were carried out. The co-existence of typhus fever with deficient ventilation and cleanliness and want of work is forcibly pointed out, but the decline which has of late years taken place in Edinburgh in the number and fatality of the visitations of this disease is ascribed by the Professor to changes in the type or constitution of epidemic diseases, rather than to any satisfactory improvement in the cleaning of the lanes and houses of the working classes. In the case of the typhoid or enteric fever, Dr. Christison thinks that something more is to be looked for in endeavouring to decide upon its mode of origin than ill-drained streets, defective water-closets, and foul air. All these circumstances certainly favour its invasion, but its true cause lies in something more specific, and whilst better drainage and more perfect ventilation ought to be encouraged, yet they alone are not sufficient to extirpate enteric fever. These statements are in opposition to much that recent writers, both medical and non-medical, have been for many years back strongly inculcating, and, as was naturally to be expected, have not been allowed to pass unchallenged. But we cannot help thinking that as the deliberately expressed opinions of a physician, who has possessed opportunities of studying fever second to no man, they are deserving of much careful consideration. From a statistical comparison of the mortality of the large towns of Scotland with the agricultural counties, the greater frequency of the diseases dependent on a depraved state of the constitution in the former than the latter is, as might naturally be expected, clearly proved. The address concludes by showing that the Western Islands of Scotland, in spite of their mist-laden atmosphere and exposed position, enjoy an almost complete immunity from pulmonary consumption.

XI. ZOOLOGY AND PHYSIOLOGY.

Professor Owen has made a Report upon the departments of Natural History in the British Museum for the year 1862, which speaks favourably of the general condition of the collection as to preservation, though, as far as the stored animals in the vaults—many thousands in number—are concerned, each successive year of such storage increases the difficulty of keeping the specimens in a good state. The skins of Mammalia and Birds are in good condition, and available for scientific examination, though exhibiting some signs of the effects of damp. The Insects and Crustacea are also easily available, and in good condition; but the Mollusca in spirits are so crowded, that access to the specimens not in the front row is difficult and hazardous, and their utility greatly abridged. The exhibited specimens in the various galleries are described as showing only the degree of detriment which is inevitable from exposure, with the utmost amount of care; but these are in general so crowded as to impair their utility. The additions to the Zoological department in the year 1862, were 13,129 in number, including several great rarities and valuable specimens, such as *Troglodytes vellerosus*, a new anthropoid ape, discovered by Captain Burton in the Cameroon mountains of West Tropical Africa; a new tortoise (*Cyclemys Mouhotii*), from the Lao Mountains in Cochin China; three or four new species of crocodiles; 1,911 fishes have also been added, many of them new species, and of them 128 have been placed in the British Collection.

M. Thury, Professor in the Academy of Geneva, has made a discovery, which, if it be corroborated, will be one of the utmost value in the farm and homestead. He has arrived at a formula for obtaining cattle of either sex *at will*. The duration, character, and signs connected with the period of heat in the cow upon which it is proposed to experiment must be first ascertained. These being known, in order to ensure a cow-calf congress must be effected on the first appearance of the access of this period; while a bull-calf may be as certainly ensured, by making use of the termination of this period. It is necessary to exclude from the experiment those animals in which the signs of heat are vague and uncertain, as is observed in fat cattle, and confined individuals; but healthy cows, and those living in the open air, must be used for the purpose. The experiments made upon cattle at Montet, appear to have been decisive, if we may judge from the following results:—"In the first place," says the breeder, "in twenty-two successive cases I have sought to obtain heifers; my cows were of the Schwitz race, and my bull pure Durham blood. I obtained the result sought for in *every case*. Having later purchased a Durham cow, I sought to obtain a pure Durham bull-calf, and succeeded, and have since obtained six other bulls, crossed between Durham and Schwitz. Altogether, I have made twenty-nine experiments, and every one has given the result sought." The importance of such a law will be evident,—and especially will such results be valuable in countries where it is desirable to obtain oxen for working purposes; as in others, cows are the most valued animals. Moreover, the same remarks will apply to *sheep*.

A series of experiments is about to be conducted on the Imperial farm at Vincennes, in order to test the value and truth of the discovery.

While on the subject of cattle, it may be well to refer to a practice adopted by M. Charlier, for the suppression of horns, an operation which may sometimes be of great advantage. In the early months of life, when the rudiment of the horn begins to appear, it may be done without danger or expense, the owner himself operating with facility. The instrument used is a kind of trephine, a small cylinder of good steel, with a sharp cutting edge at one end and a point at the other. This instrument is placed around the young horn, bearing sufficiently on it to cut through the skin and subjacent tissue at the base of the horn, and then everting the soft horn, which offers no resistance. The wound heals in a few days afterwards without suppuration, and generally without any febrile symptoms.

In the beautiful and elaborate Memoir published by the Smithsonian Institution (Smithsonian Contributions to Knowledge, xiii. 169), entitled 'Researches upon the Anatomy and Physiology of Respiration in the Chelonia,' by Drs. Weir Mitchell, and G. R. Moorehouse, some curious errors of previous writers are pointed out with regard to the respiratory movements in Turtles. All writers upon this subject, including Malpighi, Cuvier, Johannes Müller, Milne Edwards, Agassiz, &c., appear to have described the act of breathing to be performed by them thus:—by the depression of the hyoid apparatus and tongue air is drawn into the mouth through the nostrils, which are then closed; and by raising the hyoid, air is driven from the mouth through the glottis and trachea into the lungs, when inspiration is completed. Expiration being effected by the contraction of the abdominal muscles, and the consequent compression of the lungs. Instead of this, the authors of this Memoir have proved that the hyoid apparatus has nothing whatever to do with ordinary breathing, but that *inspiration* is performed by the abdominal muscles, which naturally form a deep concavity, but contracting become flat, draw down the viscera, enlarge the cavity of the trunk, which enlargement is followed by a rush of air through the trachea into the lungs, when inspiration is completed; while expiration is produced by the action of a peculiar muscle, now first completely described, like a broad digastric, which arises from the fore and hind part of the shield, and unites by a broad tendon across the middle of the abdominal cavity, between which muscle in front and the shield behind, are included the viscera—and by contraction of which *expiration* is effected. It is remarkable that this correct view has since been found by the authors to be set forth in a dissertation on the subject written at Göttingen, in 1795, by Robert Townson, LL.D., and they were surprised, on learning the singularly correct views there propounded, to find that they had ever since been either unappreciated or condemned.

Signor Trinchese has been engaged in the investigation of the nervous system of the Gasteropodous Mollusca, taking as types the Helix pomatia, Arion rufus, and Lymnæa stagnalis. He finds that in all the nervous centres of these animals there are,—round or pyriform cells of variable dimensions, enveloped in a thick sheath of connective tissue; small cells of irregularly triangular form, round which no envelope is perceived; and free nuclei, like those met with in the grey matter of the cerebro-spinal axis in Vertebrates. The cells usually present four prolongations, passing to each of the cells surrounding them, whilst other processes pass between the latter to other cells at a greater or less distance. These cells are usually found in the peripherical portions of the ganglia, the interior being occupied with fibres and conjunctive tissue. The optic ganglia consist of free nuclei and nervous fibres proceeding from the anterior part of the cerebroid ganglia, two in number. On the anterior portion of them in Helix and Arion, there are four small accessory cerebroid ganglia; and on the course of the nerves connecting the cerebroid masses with the pedal or abdominal ganglion, there is a small ganglion, composed of cells united in groups, like the compartments of an orange. The peripheral nerves are formed of very delicate tubes, having on their walls nuclei similar to those which are observed in the higher animals in the Embryonal state. Their mode of termination in the muscles is remarkable. The nervous element on arriving at the muscular fibre, loses its proper wall, and the axis-cylinder alone penetrates the muscle, dividing into two very slender filaments. These take opposite directions, each traversing one-half of the muscular fibre, on arriving at the extremity of which they terminate in very fine points.

Although we have long been acquainted with the young state of the true crabs, and hermits, under the form known as Zoëa, especially distinguished by the want of the ten feet to which the adult animals are indebted for their name of Decapoda, it is only recently that Fritz Müller has described the Zoëa forms of the Porcellanæ as approaching most closely to those of the crabs. He has now added the interesting fact that in certain Prawns and Stomapoda (as probably Squilla mantis) similar conditions occur. The metamorphosis of the former commences sometimes (as in the Cirripeds) with monoculoid forms, and passes through very peculiar Zoëoid and Mysis-like states, sometimes with Zoëa forms which in structure and mode of movement resemble those of Hermit Crabs, whilst in others we can hardly say that there is any metamorphosis. Dr. Müller has, however, described and figured a little animal which he considers the Zoëa of a Stomapod, of glassy transparency, in which the segments exist in almost the same number as in the mature Stomapods, the sixth and seventh abdominal segments only being not yet distinct from each other. As in the Zoëæ of the Crabs and Porcellanæ, the appendages of the sixth hinder thoracic segments, and the lateral laminæ of the caudal fin were also as yet entirely deficient. They possess only a median eye.

So little is known of the habits and modes of life of marine animals, that we cannot but feel much interested and deeply indebted for carefully observed facts in this department. Such are those of the curious relations existing between the Crab, Pagurus Prideauxii, and the Zoophyte, Adamsia palliata. These two incongruous animals are, it is well known, constantly found associated together, and although we have found them difficult to keep alive in an aquarium, Lieut.-Col. Stuart Wortley has been more successful, and has observed the crab, after eating two pieces of meat given to it, seize a third with its large claw, and thrust it into the expectant mouth of the Adamsia. This has been frequently repeated. On leaving its shell, for the purpose of establishing itself in a new one, the Pagurus returned to the old shell, and dislodged the Adamsia with its pointed claws, during which rough process no acontia were thrown out, as would be done on the slightest irritation from any other source; and when entirely separated, the crab holds it firmly with its base against the new shell until it has affixed itself. It remained on one occasion for an hour in this position, when, finding Adamsia did not affix itself readily, it returned to its old shell upon which Adamsia firmly attached itself as before. So attached does the crab appear to be to its helpless companion, and so loath to quit its hold upon it, that Col. Wortley concludes, as we were inclined to do from facts observed in dredging when they were abundant, that Adamsia palliata is almost, if not quite, a necessity of existence to Pagurus Prideauxii. The converse, however, cannot be said, for we have kept a specimen of Adamsia alive for twelve months unattached to any shell, the Pagurus having died on the day succeeding its capture.

Another remark on the habits of Crustaceans has been furnished by Mr. Moore, Curator of the Liverpool Museum, in reference to the King Crab (Polyphemus) of which several living specimens have been sent over by Professor Agassiz. The long spine-like tail of this species has excited much question as to its use. If they are turned over on their backs, they bend down the tail until they can reach some *point d'appui*, and then use it to elevate the body and gain their normal position. The function assigned to it by some, *viz.* of placing it under the body and leaping from place to place, has never been observed.

Rudolf Leuckart has made some interesting observations upon the development of the *Acanthocephali*, the only group of *Entozoa* whose development had hitherto eluded the investigations of naturalists. Scattering the ova of six or eight *Echinorhynchi* of the species *E. proteus* in a bottle containing *Gammari*, he found in a few days a great number of these ova in the intestines of the Gammari. The embryos quitting their envelopes passed into the abdominal cavity of the Crustaceans. After three or four weeks the embryo underwent a singular metamorphosis, which converted its nucleus into a true Echinorhynchus, like an Echinorderm in its Pluteus. This rapidly increases in size, and finally fills the body of the embryo, which becomes transformed into the envelopes external to the muscular tube of the worm, and distinguished by a proper vascular system. When the spinous armature of the head is formed, it draws back into the posterior part of its body like a *Cysticercus* in its vesicle. Leuckart has counted fifty or sixty parasites in a single Gammarus.

Considerable attention has been devoted to the characters of the

Amœbina, by two gentlemen who, though they do not agree in all their results, will no doubt by a friendly rivalry the better tend to elucidate the truth. These are Dr. Wallich and Mr. H. J. Carter. Dr. Wallich insists upon the absolute necessity of long-continued and daily observation whenever it is desired to elucidate the characters and vital phenomena which appertain to the lowest forms of organic existence; and entertains the view that probably many, if not all, the previously described species of Amœba are referable to, and constitute mere phases of *Amœba villosa*, the most highly developed type. Mr. Carter, however, regards certain characters of primary importance, and typical of *A. princeps* (Ehr) as reconstituted by him, while Dr. Wallich urges these characters as distinctive of *Amœba villosa* as already described by him. The characters which Mr. Carter claims for his *A. princeps* are its large size and the number of granules it contains; its limacious though protean form, its lobed and obtuse pseudo-podia proceeding from a posterior end, normally capped with a tuft of villous prolongations; while the nucleolus is so much extended over the inner surface of the nuclear cell, that it passes beyond the equatorial line of the latter, preventing any halo round the nucleus, as in other Amœbæ; but the border of this nucleus is wavy when it has attained the 450th of an inch in length. The anomaly in the configuration of the nucleus, however, Mr. Carter afterwards resigns as a distinctive character. With regard to the apparent circulation in these low organisms, Dr. Wallich believes that it is not a vital act, but a secondary and mere mechanical effect consequent on the inherent vital contractility of the sarcode. The particles simply flow along with the advancing rush of protoplasm, and there is no return stream. The numerous and lengthy papers of Dr. Wallich and Mr. Carter, in the 'Annals of Natural History,' on the subject of these organisms tend to the combination not only of species, but of genera which have always hitherto been regarded as perfectly distinct.

The difficulty of distinguishing the lowest animal forms from vegetable bodies has received a good illustration from some observations of Mr. H. J. Carter, well known for his papers upon Rhizopods, on *Difflugia.* He has shown in this species (*D. pyriformis*) that chlorophyll cells exist as part of its organization, and that starch cells, until recently believed to be a peculiarly vegetable product, form part of its products. Moreover, he has observed conjugation similar to that of the contents of the cells of *Spirogyra*, and that apparently after this conjugation, when the body of the *Difflugia* is densely charged with chlorophyll cells and starch granules, the nucleus becomes charged with spherular, refractive, homogeneous bodies, which appear to be developed in the protoplasm that lines (?) the nucleus. These spherules pass from the nucleus into the body of the animal, and there, becoming granuliferous, so increase by duplicative division, as to form the chief bulk of the whole mass, while the chlorophyll cells have *entirely* disappeared, and the starch granules have become more or less diminished in number. Colourless specimens of Difflugia having been placed in water, after four days the bottom of the vessel became covered with granuliferous cells of the same size and appearance as those peculiar to the colourless specimens, but with the difference that they were all provided with a cilium (perhaps two); most were fixed and retained their globular form; others swam about by means of their cilium; many of the fixed globular forms altered their shape by becoming polymorphic; and some lost their cilium and became altogether reptant and amœbous. There can be little doubt that these Amœbæ are the young brood of *Difflugia pyriformis.* Thus the cycle of generative development in this Rhizopod by "granulation of the nucleus" is so far completed. It is probably the same as in *Amœba princeps.* The development of the young *Amœba* into adult testaceous *Difflugiæ* has not yet, however, been observed.

We should hardly be prepared for psychical development in these minute masses of sarcode, nevertheless Mr. Carter's observations of Æthalium and Actinophrys render it probable that certain manifestations of instinct are occasionally evinced by them, of the same kind as those in the higher animals. On one occasion, for example, Mr. Carter observed an Actinophrys station itself close to a ripe spore-cell of *Pythium*, which was situated upon a filament of Spirogyra, and as the young ciliated germs issued forth, one after another, from the dehiscent spore-cell, the Actinophrys remained by it, and caught every one of them even to the last, when it retired to another part of the field, as if instinctively conscious that there was nothing more to be got at the old place. As, however, these lowest forms of life appear to have but one object, and that the attainment of food, we cannot be so much surprised if they are provided with sufficient discrimination to be aware when they are receiving it, and when the supply has ceased. Indeed their whole instinctive development is concentrated upon that important end.

REVIEWS.

THE BIRDS OF INDIA.*

The want of text-books on the Natural History of our colonial and foreign possessions, has been long and severely felt by the many residents in them who are desirous of employing their hours of leisure or recreation, in the pursuit of this most attractive study. As regards Botany, the energy of the Director of the Royal Botanic Gardens at Kew has already accomplished much towards the attainment of this desirable object. Some years since, Sir William Hooker's urgent representations to the Colonial Office succeeded in inducing that department to take into consideration a scheme which he propounded, for issuing a complete series of Manuals of the Botany of the different Colonies, and although the small sums necessary to effect this object were, with one exception, grudged to him by the Imperial Exchequer, the Colonies themselves have in many instances taken up the matter, and there is little doubt that Sir William Hooker's scheme will eventually be carried out in its integrity.

Our zoologists have not as yet followed the good example thus set before them. Their field of operations is much more extensive, they are less united as a body, and they have certainly no single leader amongst them, who occupies a corresponding situation to that filled by Sir William Hooker with regard to the sister science. So far as concerns the zoology of our foreign and colonial possessions, therefore, we must for the present look to what the unassisted energies of private individuals can accomplish. And we must be thankful when even such indirect sanction and assistance as the Government of India has bestowed on Dr. Jerdon's present undertaking can be obtained.

Dr. T. C. Jerdon's name is well known in connection with many contributions to the Natural History of India, which he has made during a long service, in different parts of that country, as a medical officer of the Indian army. In 1839, Dr. Jerdon commenced the publication in the 'Madras Journal of Literature and Science' of a catalogue of the birds of Southern India. This with its supplements was completed in 1844, and still remains our best authority on the ornithology of the districts of which it treats. In 1844, Dr. Jerdon

* 'The Birds of India: being a Natural History of all the Birds known to inhabit Continental India; with Descriptions of the Species, Genera, Families, Tribes and Orders, and a Brief Notice of such Families as are not found in India; making it a Manual of Ornithology specially adapted for India.' By T. C. Jerdon, Surgeon-Major, &c. Calcutta, 1862. Vols. I. and II. pt. 1.

also published a series of illustrations of Indian birds,* in a quarto volume of fifty plates, in which many rare species were figured for the first time. Besides this, he has contributed many papers relating to Indian zoology to different scientific journals, and has been a most indefatigable explorer and collector in nearly every province of India. It cannot be doubted, therefore, that Dr. Jerdon's qualifications to carry out the plan he now proposes,—that is, to issue a series of Manuals of the Natural History of the Vertebrated Animals of India,—are very considerable. And looking to the way in which he has commenced to execute his plan, in the case of the two volumes now before us, which form the first part of his 'Manual of Indian Ornithology,' we have every reason to be satisfied that it has fallen to his lot to undertake it. Nor can it be doubted that such a series of manuals is a great desideratum. At present, as Dr. Jerdon observes, to "obtain acquaintance with what is already known respecting the Fauna of India," it is necessary to "search through the voluminous transactions of learned societies and scientific journals," which are of course quite inaccessible to residents in an Indian up-country station, and hardly to be referred to even in Madras or Calcutta. Dr. Jerdon's aim, therefore, is to supply in a few portable volumes the information requisite for a student of any branch of the natural history of the vertebrata of India to ascertain what is already known of his favourite science and to what points especially he should direct his inquiries. The two volumes already published by Dr. Jerdon take us through the greater part of the class of birds; a third volume, shortly to be issued, will complete this part of the subject. The author will then turn his attention to the Mammals, Reptiles, and Fishes, and treat of each of these classes of animals in a similar manner.

Dr. Jerdon introduces himself to his readers in the first volume of his present work with a well-written chapter of general remarks, which will repay perusal. After giving an outline of the structure of birds, external and internal, and some remarks on their migration, he proceeds, before entering upon the subject of classification, to devote a few words to the much-vexed question of the differences between species and variety. A *species*, Dr. Jerdon defines as consisting of a "number of individuals closely resembling one another in size, structure, and colour, and propagating a like race;" a *variety*, as "consisting of one or more individuals resembling certain other individuals sufficiently to be considered identical in species, and yet differing in certain external points of colour, size, or form." As regards the mode in which this difficult subject, as encountered in the case of the birds of India, has been dealt with, the following remarks of our author may prove of interest:—

"Some naturalists believe that permanent varieties are common in the animal kingdom, and Kaup calls them *sub-species*. Such persons consider that their differences from other individuals, of what they would term the typical form, do not entitle them to the full rank of a species. Others, again, deny that permanent varieties exist, and state their conviction that

* 'Illustrations of Indian Ornithology.' By T. C. Jerdon. Madras, 1844. 1 vol. 4to.

even slight differences of colour and size, if found to be constant, are sufficient to constitute such individuals a distinct race or species. When such differences are found to co-exist with a different geographical distribution, I certainly prefer the views of those who look on all permanent distinctions of colour, size, structure, &c., as distinct species; and I believe that no change of climate, or food, or other external circumstances, will produce any alteration in them or in their descendants, if they remain true to each other; and as yet I know of no recorded instance where any well-marked race has produced offspring differing from their own, or tending to revert to a supposed original type. That various nearly-affined species will propagate *inter se*, and produce fertile offspring, I fully believe; as in the cases of the green Pigeons of Bengal and of Southern India, in the Indian and the Burmese Rollers, the small Cuckoos of South India and those of Bengal, and in several other instances: but that this fact militates against their being species and in favour of their being varieties, I think is not supported by many recent experiments in crossing. Of late years many species have been universally admitted as such, which were formerly considered simple varieties, and although, perhaps, the tendency of late writers has been to multiply species, in some cases most unnecessarily, yet in previous years the other extreme was taken, more especially by Schlegel and his followers. Our best naturalists and ornithologists now fully recognize the distinctness of permanent races. If varieties are once allowed, it depends on individual judgment or caprice to what extent they may be carried. In this country, where there are many very closely allied species, among genera characteristic of the country, many of the species of *Malacocercus* and *Hæmatornis* would be classed as simple varieties by some, whilst others would perhaps allow some of them, whose different notes they might have observed, to be distinct species, and the rest varieties. Lastly: it is, I think, more convenient in practice to give each race a distinct specific name, than to speak of them as '*Var. A.*' or '*Var. B.*' of such a species."

With regard to the origin of these allied or "representative" species, as they are usually termed, Dr. Jerdon states that, as far as his "brief experience goes, geographic distribution is against Mr. Darwin's theory. "To give one instance," he continues, "*Malacocercus striatus* of Ceylon is more allied to *M. Bengalensis* of Bengal, than to *M. Malabaricus*, which is spread throughout a vast region between those provinces." On this point we may remark that the great mass of evidence in such cases is, as is now generally allowed, decidedly on the other side of the question. It is beyond a doubt, that allied species, are as a rule, distributed geographically in the order of their affinities, that is, that the most nearly allied occupy conterminous areas. Moreover, Dr. Jerdon ought to be aware that Ceylon, though now-a-days much more nearly connected with the peninsula of India, than with the upper provinces, furnishes many remarkable forms which tend to show that this island has been peopled with life from the other side of the Bay of Bengal, along which the Bengalese species descend, often far to the south. Dr. Jerdon, however, seems to take a very candid view of Mr. Darwin's theory on other points, though he is of opinion that that distinguished naturalist, "perhaps, lays too much stress on external and fortuitous circumstances as producing varieties, and not enough on the inherent power of change."

Dr. Jerdon next proceeds to the difficult subject of the classification of birds, and adopts as his system, nearly that of Mr. George Gray, as given in his 'List of Genera.' Finally, he concludes his introduction with a sketch of the physical features of Northern, Central, and Southern India, in relation to their respective Faunas, and gives some account of what has already been effected by different naturalists who have devoted their attention to various points of the area embraced in these three divisions. The names of Franklin, Tickell, Sykes, and Hodgson are all well known in connection with the earliest researches made in Indian Ornithology. The latter gentleman especially, who was for many years resident at the Court of Nepaul, laboured long and zealously in this, as in other branches of Natural History, and has effected far more than any other naturalist towards making known to us the many singular forms of life that people the slopes of the Himalayas. Other more recent workers in the same field have been Burgess, Adams, Tytler, and McClelland, and last, but not least, Mr. Edward Blyth—for many years the energetic and devoted curator of the Asiatic Society's Museum at Calcutta, whose numerous publications and extensive researches have, as rightly observed by Dr. Jerdon, done more to extend the study of Natural History in India than those of all the previously mentioned observers put together.

We now come to the main portion of Dr. Jerdon's work, which consists of short treatises on each of the species of birds belonging to the Indian Avi-fauna, interspersed with current allusions to the various groups found in other countries, but not represented in the Indian series. Dr. Jerdon's two published volumes treat of the Birds of Prey and the numerous divisions of Insessores or Perchers. Of the first, he gives 81 species as belonging to the Fauna of India, of the Insessores, no less than 689 species are enumerated. Such being the case, it could not be expected that any very detailed account could be given of each bird, especially as what is contemplated is a "brief, but comprehensive Manual." And on the whole, as regards the first volume especially, we cannot but think that we have every reason to be satisfied with the way in which our author has performed his work. The descriptions given are sufficient for the determination of the species in ordinary cases. In many allied forms, it will, of course, be necessary for the student to refer back to the previously published accounts indicated among the synonyms of each species, and in the more difficult cases, to go to the typical specimens in the Museum of Calcutta, or of the British metropolis. The details as regards the geographical distribution, habits, and general alliances of each species are likewise carefully worked out, and the whole account is written in plain and comprehensible terms, well suited for the purpose intended. As an illustration of Dr. Jerdon's style, we extract his remarks on the *Turumti* Falcon (*Hypotriorchis chicquera*)—one of the best known, and commonest small Falcons of India, allied to our Hobby.

"The *Turumti* is universally spread throughout India from north to south, but is rare in the forest districts, as it affects chiefly open country in the vicinity of cultivation. It frequents gardens, groves of trees, and even large single trees in the open country, whence it sallies forth, sometimes circling aloft, but more generally, especially in the heat of the day, gliding with inconceivable rapidity along some hedgerow, brink of a tank, or across some fields, and pouncing suddenly on some lark, sparrow, or wagtail. It very often hunts in pairs, and I have now and then seen it hover like a kestrel for a few seconds. It preys chiefly on small birds, especially the social larks (*Coryphidea calandrella*), sparrows, and the small ringed-plovers (*Charadrius*); also not unfrequently on bats, which I have seen it seize on the wing just at dusk. It breeds on high trees, and has usually four eggs of a yellowish-brown colour, mottled with brown spots. The young fly early, by the end of March or beginning of April. It has a shrill angry scream, and is very courageous, driving away crows, kites, and even the wokhab (*Aquila fusca*), from the vicinity of its nest or perch. It is occasionally reclaimed, and flown at quail, partridges, mynas, but especially at the Indian Jay or Roller (*Coracias indica*). In pursuit of this quarry the Falcon follows most closely and perseveringly, but is often balked by the extraordinary evolutions of the Roller, who now darts off obliquely, then tumbles down perpendicularly, screaming all the time, and endeavouring to gain the shelter of the nearest tree or grove. But even here he is not safe; the Falcon follows him from branch to branch, drives him out again, and sooner or later the exhausted quarry falls a victim to the ruthless bird of prey. I have known falconers train the *Turumti* to hunt in couples.

"The Indian name, *Turumti*, appears to owe its origin to *Turumtai*, given by Pallas as the Calmuc name of the Hobby.

"A very nearly-allied species of Martin exists in Africa, *F. ruficollis*, Sw. (*chicqueroides*, A. Smith), long considered as the same, but now recognized as distinct by Hartlaub and others. Kaup, P.Z.S. 1851, calls it a sub-species of the other, differing in its darker colours, more striped head, and with the cheek-stripe darker and more distinct."

The second volume of Dr. Jerdon's work is, perhaps, not quite so satisfactory as the first. The descriptions given are mostly shorter and more concise, and we do not find so many of those agreeable episodes upon the habits of the species which tend to render a book of this sort acceptable to the ordinary reader. Yet we must recollect the extent of the subject,—the immense number and variety of the little Passerine birds, of which this part of Dr. Jerdon's book treats,—and how difficult it is to say much when the subject is so new, and when so little, considering the wide field of observation, has been done by former workers. As it is, Dr. Jerdon has already transgressed the bounds originally marked out for himself,—his prospectus having announced the completion of the birds in two volumes. It is perhaps, therefore, hardly fair to find fault with our author on these grounds, though, we think, the Indian field-naturalists, for whose benefit mainly the work was undertaken, will agree with our remarks upon these points.

We have now, in conclusion, one or two criticisms to make upon points which will interest our scientific readers. Dr. Jerdon adopts, as we have already stated, Mr. George Gray's arrangement of the class of birds, and, so far as the six great ordinal divisions (given p. xxxix.) go, we are not aware that he could have much improved upon them. But when he proceeds (p. 151) to employ Mr. Gray's subdivisions of the great group of *Insessores*, Dr. Jerdon is certainly behind the age. It has long since been most satisfactorily demonstrated that the *Tenuirostres* of Cuvier form a most ill-assorted group, which ought to be divided amongst the others in any natural arrangement, and that, exclusive of the Parrots, there are but three natural sub-groups of Insessorial birds,—namely, the *Fissirostres*, *Scansores*, and typical *Passeres*. We might also object to Dr. Jerdon's collocation of the Swifts and Swallows, to the situation he has assigned to *Upupa*, and to many other minor points. But on the other hand we must congratulate him on his giving the *Megalæmidæ* their true rank as a distinct family, on his correct appreciation of the relation of the Hornbills, and on much that relates to his general arrangement of the smaller groups. On the other hand, Dr. Jerdon goes too fast in another direction, especially when it is recollected that his book is intended for learners and unscientific persons as well as for the initiated. The subdivision of the Genera is carried to by far too great an extent, and this, in our estimation, forms one of the principal defects of the book as a scientific work. The best authorities of the day, in all departments of natural history, set their face against this indiscriminate multiplication of generic terms, which, as carried out by certain writers, bids fair to convert every species into a genus, and renders the burden of recollecting technical names almost insupportable. Generic differences ought to be founded on essential and easily recognizable points of structure. That this is not the plan followed in Dr. Jerdon's book, every naturalist will very soon discover, and we fear the non-naturalists (if we may so express ourselves) will be sorely puzzled in their attempts to fathom many of Dr. Jerdon's minute subdivisions of well-known groups. Who will recognize the Linnæan *Turdi* under the names *Turdulus*, *Planesticus*, and *Geocichla?* Who will appreciate the separation of the well-defined genus of Pipits (*Anthus*) into *Pipastes Corydalla* and *Agrodroma?* In thus following the phantasies of Kaup, and the mad vagaries of Bonaparte (in his latest writings), we cannot believe that Dr. Jerdon has acted well for his own reputation, nor wisely as regards the class of readers for whom his volumes are specially intended.

NATURAL HISTORY ON THE AMAZONS.*

To no class of men are the thoughtful students of Natural History more deeply indebted than to those who, casting behind them all the luxuries and pleasures of civilized life, plunge into the forests and solitudes of far distant regions, there to hold communion with Nature face to face, and to obtain an insight into her workings and modes of action in situations which, under ordinary circumstances, would for

* 'The Naturalist on the River Amazons.' By Henry Walter Bates. 2 vols., 8vo. London: John Murray, 1863.

'Contributions to an Insect Fauna of the Amazon Valley; Lepidoptera, *Heliconidæ*.' By Henry Walter Bates. ('Linnæan Transactions,' vol. xxiii. part 3, page 495.)

ever be concealed from intelligent curiosity. The framers of theories, and the elaborators of grand generalizations, must necessarily own their dependence upon such self-sacrificing investigators, and the value of the facts accumulated by such men depends upon their own inherent powers of observation, and the degree of intelligence and industry they bring to bear upon their self-imposed labours. And seldom indeed does it happen that these qualities are so admirably combined as they appear to be in one whose ardent thirst for natural knowledge impelled him to exile himself for eleven years in a tropical and unhealthy country, in order that he might revel in the rich prodigality of animal and vegetable life which characterizes the great valley of the Amazons—a region which, though far indeed from the comforts and necessities of civilization, may fitly be designated "the Metropolis of Nature."

Mr. Bates embarked at Liverpool in the spring of 1848, in company with Mr. A. R. Wallace, for Pará, the only port of entry to the vast region watered by the Amazons. The object which the travellers proposed to themselves was twofold—to make for themselves collections of specimens, consigning the duplicates to London, to be there disposed of in payment of expenses, *and*, to gather facts towards solving the problem of the "origin of species." The first of these objects was attained in an eminent degree; for not only have Mr. Bates's collections many a time and oft caused congregations of naturalists under the hammer of Mr. Stevens, but he astounds us with the statement of his aggregate results when he informs us, with truthful simplicity, that he obtained, during his eleven years' sojourn, 14,000 insects, and 712 other animals, of which startling total no less than 8,000 were *new to science.* Never has it fallen to the lot of a single individual to bring so vast a contribution to systematic zoology, and it is a grand proof of the rare riches of the teeming district he so wisely selected for his exploration.

With regard to the second object of the journey, while the results have not been so definite as those just glanced at, the two explorers arrived at some conclusions to which we shall refer in the course of the present article, and which, however widely they may differ from the views of another school, will, we venture to predict, be of considerable service in the ultimate advance of science. It is now a matter known to every one, that Mr. Wallace, after spending four years in South America with Mr. Bates, travelled to the East in search of new fields of exploration, and there, while lying stricken down by fever, he elaborated in his busy brain the theory afterwards promulgated by Mr. Darwin in his work on 'The Origin of Species.' It was this fact, and the communication of this hypothesis to Sir C. Lyell, which determined Mr. Darwin to bring his long-cherished views before the Linnæan Society, and thereafter to publish the book which has been so fertile a source of scientific controversy. We may judge, therefore, that as far as Mr. Wallace is concerned, he considered that the facts he had collected threw some light upon the problem which they had charged themselves to illuminate. And in the work before us Mr. Bates proves himself an apt scholar and valuable ally of Mr.

Darwin; and in his preface he tells us that it was Mr. Darwin's opinions and wishes which were mainly instrumental in inducing him to commence the inditing of his book, and the same steady encouragement which strengthened his wavering resolution, and helped him to accomplish the task. We shall not be surprised, then, to find the tendency of the book to be Darwinian.

Mr. Bates made Pará his head-quarters, and his first volume is devoted to that neighbourhood, and his excursions up the Lower Amazons. The zoological richness of the immediate vicinity of Pará itself is something almost beyond belief; and our traveller's account of his first walk on the afternoon of his arrival is most graphic and stirring. Nevertheless he appears to have been at first struck with the generally small size and obscure colouring of the birds, and the similarity of appearance which the insects and birds of the open, sunny places bore to those inhabiting similar spots in Europe. The roadside vegetation consisted of tangled masses of bushes and shrubs, intermingled with prickly mimosas; but, notwithstanding this resemblance to European roadside features, there were, as may be supposed, many others which, at every step, reminded the travellers that they were in another world. The abundance of climbing trees attracted the attention in their first forest walk, and elicited a remark which is extremely interesting, *viz.* that these climbing trees do not form any particular family or genus; there is no order of plants whose especial habit it is to climb; but species of many, and the most diverse families, the bulk of whose members are not climbers, seem to have been driven by circumstances to adopt this habit. The orders Leguminosæ, Guttiferæ, Bignoniaceæ, Moraceæ, and others, furnish the greater number. There is even a climbing species of palm (Desmoncus). This remark is very characteristic of the tendency of Mr. Bates's mind, which, though not to an undue degree speculative, yet sees, in observations like these, something more than the meagre fact which would be patent to all. He concludes the subject with the remark: "The number and variety of climbing trees in the Amazons forests are interesting, taken in connexion with the fact of the very general tendency of the animals also to become climbers." (p. 49.)

The quadrupeds and birds of the forest do not appear to the passing traveller, for, being excessively shy and widely scattered, the first impression which Mr. Bates received was that they were very few; he met with no tumultuous movement or sound of life, but describes it as a solitude, in which only at long intervals animals are seen in abundance, when some particular spot is found which is more attractive than others; and this fact of distribution is one which we have ourselves observed, when, for example, scanning an expanse of sea-shore in search of the smaller marine animals, in situations where certain species are known to abound. The feeling inspired in the Brazilian forests was one of inhospitable wildness, only increased tenfold by the fearful and harrowing uproar made by the howling monkeys morning and evening. Other sounds are not so easily accounted for, even by the natives themselves, such as a sudden noise like the clang of an iron bar against a hard, hollow tree, or a piercing cry which rends the air—sounds not repeated, while the succeeding silence tends to heighten the impression which they make on the mind. "With the natives it is always the Curipíra—the wild man or spirit of the forest—which produces all noises they are unable to explain." (p. 73.)

Near Cametá, on the river Tocantins, Mr. Bates had an opportunity of verifying a fact which had almost fallen into discredit, *viz.* the bird-catching propensities of the great Mygale spider (M. avicularia). Its web was stretched across a crevice in the tree-trunk, and in it were entangled two birds about the size of our English siskins; one of them was dead, and the other under the spider, not quite dead. The observation appeared to be new to the residents, though the insect was well known; and the *crab-spiders*, as they call them, are injurious even to man, from the maddening irritation produced by their hairs, which come off when touched. Nevertheless, Mr. Bates "saw the children belonging to an Indian family, who collected for me, with one of these monsters secured by a cord round its waist, by which they were leading it about the house as they would a dog." (p. 162.)

The impediments which Mr. Bates encountered in his journeys up and down the 'Great Father of Waters' almost exceed belief, owing partly to the dangers of the river navigation, and partly to the scarcity of trading-canoes large enough for his accommodation. Although but a river, a strong breeze would produce such a *sea*, that the vessel (a schooner) pitched and rolled like a ship in the ocean; and in the Tocantins, the view from the middle of the stream is described as very imposing:—"Towards the north-east, there was a long sweep of horizon, clear of land; and on the south-west, stretched a similar boundless expanse, but varied with islets clothed with fan-leaved palms, visible, however, only as isolated groups of columns, tufted at the top, rising here and there amidst the waste of waters." (I. 220.)

We cannot sufficiently admire the perseverance and earnestness with which Mr. Bates overcame difficulties that would have deterred any ordinary traveller, and encountered dangers of no insignificant nature. These difficulties and dangers are best illustrated by his account of a voyage up the Tapajos, from Santarem to the Mundurucú village. It was necessary first to procure a vessel of his own, a two-masted cuberta, of about six tons' burthen, strongly built of Itauba wood. This was hired at the cheap rate of 1*s.* 2*d.* per diem. Then men were necessary, and although only six were wanted, it was almost impossible to procure them; and at length, after almost fearing that the voyage must be given up, he procured one man, and with his servant José he determined to attempt the journey. Before they had got many miles a storm arose which blew away their boat, tore their sails to rags, snapped their ropes, and drove their vessel broadside on the beach. Nine days were necessary to repair the rigging; but not lost days, for there were rich forests to explore. Having been fortunate enough to meet with another hand, they again proceeded, and for some days all went on well, but the loss of the boat was a great source of annoyance, and ultimately was remedied by building a canoe out of a tree felled for the purpose, and moved with great labour to the river-side upon a road made for the occasion. The *casca* turned out a success. Add to all this the plagues of *fire-ants*—Tabani, which, by twos and threes at a time, dug their probosces, half-an-inch long and sharp as a needle, through the long thick cotton shirt upon their backs, making them cry out under the infliction, and a host of other inconveniences; and it will be seen that natural-history collecting upon the Amazons is no child's play.

Some curious adventures with serpents rewarded this excursion. On one occasion an Anaconda (Eunectes murinus), 18 feet 9 inches long, was systematically hunted and despatched with harpoons; and he appears to credit reports of similar serpents having been found 42 feet long. Moreover, the natives are not without faith in the existence of a great Amazonian serpent, rivalling the great sea-serpent itself in magnitude. On another occasion, "whilst pinning an insect, I was rather startled by a rushing noise in the vicinity. I looked up to the sky, thinking a squall was coming on, but not a breath of wind stirred in the tree tops. On stepping out of the bushes, I met face to face a huge serpent (Boa Constrictor) coming down a slope, and making the dry twigs crack and fly with his weight as he moved over them. I had very frequently met with a smaller boa, the Cutim boa, and knew from the habits of the family that there was no danger; so I stood my ground. On seeing me, the reptile suddenly turned, and glided at an accelerated pace down the path. Wishing to take a note of his probable size, and the colours and markings of his skin, I set off after him, but he increased his speed, and I was unable to get near enough for the purpose. There was very little of the serpentine movement in his course. The rapidly moving and shining body looked like a stream of brown liquid flowing over the thick bed of falling leaves, rather than a serpent with a skin of varied colours. The huge trunk of an uprooted tree here lay across the road; this he glided over on his undeviating course, and soon after penetrated a dense swampy thicket, where, of course, I did not choose to follow him."

Having stayed about three years and a half at Santarem, and in its neighbourhood, Mr. Bates proceeded to Ega, on the Upper Amazon, or Solimoens, and this distant spot, 1,200 miles from Pará, he made his head-quarters for no less than four-and-a-half years, making during that period, however, excursions of 300 and 400 miles' distance from it. An arduous journey of 35 days from Santarem brought our traveller to Ega, where, far from civilized life, he was often put to great shifts, from the failure of communication and remittances from Europe. From the inhabitants he met with civility and kindness, and although never troubled with impertinent curiosity on their part, his pursuits could not fail to arouse some speculation. The Indians and half-castes complacently thought it but natural that strangers should collect and send abroad the beautiful birds and insects of their country, universally concluding that the butterflies were wanted as patterns for bright-coloured calico prints. We can sympathize with the noble endurance of Mr. Bates, in spite of the difficulty of getting news, the want of intellectual society, and, towards the latter part of his residence, ill-health arising from bad and insufficient food; and feel rejoiced that he was well repaid by the fact that the neighbourhood yielded him, up to the last day of his residence, an uninterrupted succession of new and curious forms in the different classes of the animal kingdom, but especially insects.

It is difficult, from such a mine of information as is displayed in the contents of these two volumes of travel, to select for illustration one subject of considerably greater interest than another. Mr. Bates discourses of monkeys, of serpents, of birds, of insects, of vegetation, of natives, and all with the air of one who speaks of what he has seen. But it is to insects more especially that his attention was directed, and if we were to single out one subject in particular which he has thoroughly studied, it would be that of the history of the various species of Ants, the Saüba Ant, the Formiga de Fogo or Fire Ants, the Termites, the Foraging Ants, &c., for the graphic and interesting accounts of which, however, we must refer the reader to his volumes. But while it is to insects that he has devoted a large portion of his attention, it is in reference to them also chiefly, that he has advanced those views which we have already alluded to, as bearing upon the question of the origin of species; and in the remaining portion of this article we shall briefly notice those views.

Among insects, the causes and influence of colour is a very important subject, which receives its share of attention, but although the brilliant ornamentation of the males exists in the fauna of all climates, it certainly reaches a higher degree of perfection in the tropics than elsewhere; nevertheless Mr. Bates concludes that it is not wholly the external conditions of light, heat, moisture, and so forth, which determine the general aspect of the animals of a country, and he combats the generally entertained notion that the superior size and beauty of tropical insects and birds are immediately due to the physical conditions of a tropical climate, or are in some way directly connected with them. It is almost always the males only which are beautiful in colours; the brilliant dress is rarely worn by both sexes of the same species. If climate had any direct influence in this matter, why, he asks, have not both sexes felt its effects, and why are the males of genera, living under our gloomy English skies, adorned with bright colours? It is true the tropics have a vastly greater total number of species altogether; the abundance of food, high temperature, absence of seasons of extreme cold and dearth, and the variety of stations, all probably operate in favouring the existence of a greater number and variety of species in tropical than in temperate latitudes; but the contrast between the colouring of the sexes is often greater in the tropics than in any species of temperate zones, so that, in fact, beauty of colour is not peculiar to any one zone, but producible under any climate where a number of species or given genus lead a flourishing existence. These facts "all point to the mutual relations of the species, and especially to those between the sexes, as having far more to do in the matter than climate." Elsewhere he makes a remark in which we most heartily concur: "I think it is a childish notion, that the beauty of birds, insects, and other creatures is given to please the human eye. Surely rich plumage and song, like all other endowments of species, are given them for their own pleasure and advantage. This, if true, ought to enlarge our ideas of the inner life and mutual relations of our humbler fellow-creatures!"

Again, the similarity of the colour of the insect to the ground it inhabits is an interesting problem touched upon at vol. i. p. 207. This assimilation is exhibited by some and not by others, the dress of some species being in striking contrast to the colours of their dwelling-place. But, as Mr. Bates remarks—The species not so protected "has means of protection of quite a different nature, and therefore does not need the peculiar mode of disguise enjoyed by its companion;" and he properly infers, "that the fact of some species not exhibiting the same adaptation of colours to dwelling-places as their companion species, does not throw doubt on the explanation given of the adaptation, but is rather *confirmatory* of it."

Mr. Bates supports by observation Darwin's views of the competition existing amongst organized beings, and illustrates it in the vegetable world by the growth of the Amazons forest, especially by the *Murderer Liana*, a species of fig, which puts forth arm-like branches from side to side, which meet together, and clasping one another mount upwards, tightly encircling the tree which supports it with inflexible rings, till at length the tree is killed, and "the strange spectacle remains of the selfish parasite, clasping in its arms the lifeless and decaying body of its victim, which had been a help to its own growth. Its ends have been served; it has flowered and fruited, reproduced and disseminated its kind; and now when the dead trunk moulders away, its own end approaches, its support is gone, and itself also falls." Thus the Liana merely exhibits, in a more conspicuous manner than usual, the struggle which necessarily exists amongst vegetable forms in these crowded forests, when individual is competing with individual, and species with species, all striving to reach light and air, in order to unfold their leaves and perfect their organs of fructification. But "there is plenty in tropical nature to counteract any unpleasant impression which the reckless energy of the vegetation might produce. There is the incomparable beauty and variety of the foliage, the vivid colours, the richness and exuberance everywhere displayed, which make, in my opinion, the richest woodland scenery in Northern Europe a sterile desert in comparison. But it is especially the enjoyment of life manifested by individual existences, which compensates for the destruction and pain caused by inevitable competition." (vol. i. p. 56.)

But Mr. Bates's strongest article of alliance with Mr. Darwin is upon the subject of *mimetic resemblances*. This curious topic, touched upon in several places in his work, has received further elucidation in the admirable and elaborate memoir referred to at the head of this article. This memoir was read to the Linnæan Society, Nov. 21st, 1861, and long preceded, therefore, his two volumes of travel, to which we have hitherto been referring. By this memoir, entitled 'Contributions to an Insect Fauna, of the Amazon Valley,' Mr. Bates has established for himself a high rank among original investigators, and has shown powers of observation of which he may justly feel proud. For although the subject of recurrent form, or analogical resemblance, or homomorphism, or by whatever title it may be called, has attracted the attention of many naturalists, the manner in which it is here illustrated in the Heliconine group of butterflies, is equally original and acute.

Mr. Bates found that certain butterflies, so closely mocked certain others belonging to distinct groups, that though always on the watch, it required all his caution to distinguish them.* He believes that these resemblances are intended as a protection to otherwise defenceless insects, by deceiving insectivorous animals, and presumes that, seeing the excessive abundance of one species and the fewness of the individuals of the other, that the Heliconide is free from the persecution to which the Leptalis is subjected; and he seems inclined to attribute less to community of habit than we should be disposed to do, though it cannot be denied that such community is a constant concomitant of mimetism.

The bearing of this subject, upon the origin of species, is plainly

* The Heliconidæ appeared to him to be the objects mocked, because they all have the same family facies, whilst the analogous species are dissimilar to their nearest allies,—permitted, as it were, to produce the resemblance from the normal facies of the genus or family to which they severally belong. So close were the resemblances that Mr. Bates was never able to distinguish the *Leptalides* (Pieridæ) from the species they imitated, without close examination after capture. And yet the *Leptalides* belong to a family totally different in structure and metamorphosis from the *Heliconidæ*, which they imitate. Moreover, they fly in the same part of the forest, and generally in company with the species they mimic. Species of Ithomia (*Heliconidæ*) concerned in these imitations have all the character of true species, being distinct and constant. They are all excessively numerous in individuals, swarms of each kind being found in the districts they inhabit. The *Leptalides* are extremely rare; they cannot be more than as one in a thousand of the Ithomiæ. Moreover, none of these *Leptalides* have been found in any other district or country than those inhabited by the Ithomiæ, which they counterfeit. A species very closely allied to L. Lysinoë has been received from Mexico; but an Ithomia of nearly the same colours (I. Nero) also inhabits Mexico. Some other *Leptalides* exist which do not mimic *Ithomiæ*, but some other genera of the same family, as *Methona* and *Mechanitis*. "A similar series of mimetic analogies occurs in the Old World, between the Asiatic and African *Danaidæ* (or representatives of the *Heliconidæ*) and species of other families of butterflies and moths; but no instance is known in these families of a tropical species of one hemisphere counterfeiting a form belonging to the other." So, also, on the banks of the Amazons parasitic bees and two-winged flies mimic the dress of industrious and nest-building bees peculiar to this country, at whose expense they live, in the manner of the cuckoo.

An examination of the beautiful coloured plates in the Linnæan Society's memoir shows that the mimetic resemblances exhibit a minute and palpably intentional likeness, which, as Mr. Bates expresses it, is perfectly staggering; and no wonder, indeed, that he was constantly being deceived by them. Comparing *Leptalis Theonoë* with *Ithomia Flora*, or the *Ega* variety with *Ithomia Illinissa*, *Leptalis Amphione* with *Mechanitis Polymnia* (both var. *Egaensis*), and, again, *Leptalis Orise* with *Methona Psidii*, we cannot fail to be astonished at the closeness of the resemblance, particularly when taken in connection with the normal form of *Leptalis Nehemia*.

stated by Mr. Bates, as a most beautiful proof of the theory of natural selection, by showing that a new adaptation, or the formation of a new species is not effected by a great and sudden change, but by numerous small steps of natural variation and selection. Local conditions favour the increase of one or more varieties in a district at the expense of the others,—the selected ones being different in different districts, in the case of the varieties of *Mechanitis*. "With the mimetic species *Leptalis Theonoe* the case is different. We see here a segregation of local forms similar to that of *Mechanitis Polymnia*; but we believe we know the conditions of life of the species, and find that they vary from one locality to another. The existence of the species, in each locality, is seen to depend on its form and colours, or *dress* being assimilated to those of *Ithomiæ* of the same district, such assimilation being apparently its only means of escaping extermination by insectivorous animals." And indeed the abundance of the mocked species seems to show that it possesses some such immunity, and at all events lives under conditions very favourable to its increase and preservation. To exist in a certain locality, a Leptalis must wear a certain dress, and those of its varieties which do not come up to the mark are rigidly sacrificed.

It is manifestly impossible in a review to enter fully into all the arguments of the work. All that can be done is to indicate the salient points, and abstract the conclusions; and much as these speculations of Mr. Bates have interested us, we must content ourselves with this imperfect *résumé* of them, and refer those who would know more upon the subject to the memoir itself. In taking leave of Mr. Bates, however, we cannot help expressing the gratification and rare pleasure we have felt in the perusal of his 'Naturalist on the Amazons,' in which a vast amount of truthful and original information is given, in an unobtrusive and unselfish style. The world of naturalists is under a heavy obligation to him for his toilsome and laborious collection of facts, and for the interesting, though probably not less laborious, work in which they are permanently embodied. Nor must we omit thanks to Mr. Darwin, for screwing Mr. Bates's courage to the sticking place, without which perhaps the work would never have been written, or at all events have been so deferred as to impair its value. The 'Contributions to Insect Fauna of the Amazons' are an important addition to Entomological science, and however averse some may be to the theory of natural selection, no one can fail to be instructed, as well as interested, by the ingenious remarks with which Mr. Bates preludes the systematic part of the subject. We hail Mr. Bates as a worthy naturalist-traveller, and willingly and gratefully accord to him a well-earned and high position amongst those who have advanced science by patient, earnest, and original investigation.

THE GREAT METEOR OF 1863.*

Amongst the most startling of cosmical phenomena are the occasional appearances of Meteors of extraordinary size and luminosity. Coming without the forewarnings of gathering clouds and dropping rain, their sudden advent in a clear bright sky excites more astonishment in the common observer than the most vivid lightning, while the dull booming sound which follows their disappearance or explosion has more of mystery, and excites more terror than the pealing thunder which succeeds the electric flash.

Almost as transient as—

"the borealis race
Which flit ere you can trace their place,"

the scientific observer is often as much at a loss to tell whence they come and whither they go as the ordinary witness of their brilliancy. He is generally but conscious of a momentary flash of light, and on looking to the heavens sees only the trail, something like a luminous scratch in the sky, left by the passing object. A debt of gratitude is therefore due to any philosopher who, like the author of the opuscule we notice, is at the pains to collect and compare the observations of any single example made at widely distant stations, and construct from the whole a connected narrative.

On the evening of the 4th of March, 1863, at about seven o'clock, Dr. Heis, Professor of Astronomy and Mathematics in the Royal Academy of Münster, was taking a walk in the open air. The sky was clear and bright, when suddenly the whole neighbourhood was for a moment lighted up as with Bengal fire, and looking upwards the Doctor saw passing majestically across the firmament a fire-ball which seemed to increase in size until it grew as large as the moon at full. Such an appearance of course excited astonishment in all who witnessed it, and as the author was known to take an especial interest in these phenomena,† a few days brought him numerous communications on the subject. From these, some contributed by astronomers and physicists of great repute, as Baumhauer of Amsterdam, Quetélét of Brussels, and Mr. Greg of Manchester, others from writers of no scientific repute, but as country clergymen telling no doubt truthfully what they believed they saw, and also from the results of his own inquiries among the most stupid of Belgian peasants, the author has drawn up this complete account of the form, apparent size, colour, brightness of the object, as well as the trail, and the manner in which it disappeared or exploded.

* 'Die grosse Feuerkugel, welche am Abende des 4 März, 1863, in Holland, Deutschland, Belgien, und England gesehen worden ist.' Von Dr. Ed. Heis, Professor der Mathematik und Astronomie an der Königl. Akademie zu Munster. Halle: H.W. Schmidt. 1863.

The large fire-ball which was seen in Holland, Germany, Belgium, and England on the evening of the 4th of March, 1863, &c. &c.

† He had published an account of the large Fire Ball seen in Germany on the evening of the 4th December, 1861.

The Meteor appears to have been visible over a hexagonal area, the angles of which are formed by the following places:—Manchester, Brighton, Trèves, Erbach, Hanover, and the North-coast of the kingdom of Hanover. This space encloses more than 100,000 English square miles. The most distant opposite angles in the direction N.W. and S.E. are Manchester and Erbach, 553 miles apart; and from N.E. to S.W. Bremen and Brighton, 401 miles distant.

About the time of the appearance and its duration there is little room for difference of opinion. The author calculates the mean time for Münster at 7h. 6m., and the duration is variously stated to have been from 3 to 6 seconds.

The form and size of the fire-ball are naturally open to wider differences of opinion among the observers, but in this instance the differences are capable of reconciliation. One observer compared the head of the Meteor to the head of a fish, and remarked that it progressed with the movement of a swimming fish. Another compared it to a club, the length of which was three times that of the breadth. The majority observed that it was pear-shaped, egg-shaped, or fig-shaped; hence the author concludes that it was really ellipsoidal. But as most on the Belgian side described it as a "fiery cannon ball," the author infers that the longer axis was directed towards that side.

The apparent size was mostly compared with some terrestrial object. It was said to have been the size of a man's head, a child's head, a hen's egg, or a ball 4, 5, or 6 inches in diameter. Many said it was the size of the moon, others that its diameter was $\frac{1}{4}$, $\frac{1}{3}$, or $\frac{1}{2}$ that of the moon. One observer describes it as four times the size of the evening star, and another says that at its first appearance it was no larger than ordinary star dust (Sternschuppe).

The description of the colour, also, offers some differences. Some say it was of dazzling whiteness, others, a greenish blue, while another remarks that the light resembled that of the Electric spark.*

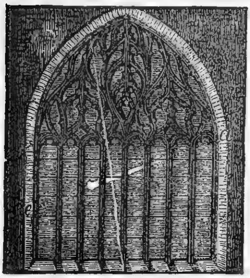
The colour, however, appears to have been changed by intervening media, so that at some stations it was said to be red, deep yellow, dark red, or violet. The author believes that the real colour of the Meteor was red, inasmuch as it appeared of that colour when at a great height, and in bright moonlight.

The most extraordinary brightness was remarked everywhere; it seemed like the sudden appearance of a full moon in the heavens. Near Boppard, an observer on a mountain saw for a moment the valley of the Rhine lighted up as by a very bright full moon. At one place, a clergyman could distinguish the letters in a newspaper lying on his table, and at Eupen a man could see to read in the street. The shadows of objects were thrown remarkably sharply and well defined; and the confused dance of the shadows of houses and trees, projected as

* The Reviewer, who was passing along Regent Street, London, on the evening in question, was much startled by the sudden appearance of an extraordinary light, which, to him, appeared exactly like the light of the electric spark. On looking to the sky, he saw nothing but a brilliant line of light which appeared to lie nearly East and West, and seemed three or four yards long.

the Meteor darted over the "Domplatz" of Münster, formed a most peculiar sight.

The Meteor was seen through the large western window of the Cathedral of Münster (as is shown in our illustration), by an observer within the building, and this appearance furnished the author, as we shall presently see, with the most important elements from which to determine its height and direction. So near to the earth did it appear at Münster, that people ran to the common before the Castle to find it, thinking it must have fallen on that spot. It was sought for by the peasantry in many places, and in one, as we shall see, by the author himself; and we are by no means astonished to read that at a village near Trêves, the peasants said that a fiery cross had fallen from heaven.



Appearance of the Meteor passing the west window of Münster Cathedral.

As is usually the case, the fire-ball of the 4th of March left behind it a line of light which showed for a few moments the direction it had taken. By some, this is described as a simple straight line of light, and by others, as a trail of sparks. One clergyman, however, denies that it left a trail, and the author accounts for the invisibility by showing that from the geographical position of the observer, the trail must have been covered by the object itself.

The disappearance is variously described by different observers. In most places they agree that the Meteor suddenly appeared and as suddenly disappeared, like lightning. But some assert, that it gave off sparks and burst like a rocket; others say that it burst into small pieces, which seemed to be entirely consumed, while one declares that it disappeared in blackish vapours, which the author does not appear to believe.

In general it has been remarked that the apparent extinction of an object such as that we are describing, has been attended by a noise resembling distant thunder. It has invariably been heard when meteoric stones have subsequently been found. No fragment of the fire-ball of the 4th of March has yet been traced, but it is certain that observers, far and near, say they heard a noise. It was not heard in large towns, even when they lay near to the spot at which the ball disappeared; but that can be easily accounted for. In some places the sound is said to have resembled the rushing noise made by a rocket in its flight, or a passing cannon-ball; in others, it is compared to the dull 'bump' which follows the fall of a heavy body on soft earth. We must remark, that the noise waa heard loudest in North Brabant, and appeared most distant at Hanover, from which important consequences follow.

Respecting the true path of the Meteor, the observations which reached the author left him in no doubt. All the observers in the east saw the object towards the west, going from right to left; while those in the west saw it towards the east, and going from left to right

There were others who supposed it to be going towards the zenith. Two reliable observations further afforded him the means of calculating with some certainty, both the direction and the height. One of these was the observation made in the Münster Cathedral. The large west window of the cathedral was suddenly lighted up, so that the architectural details were all rendered plainly visible, and the observer saw the ball pass across in an oblique direction from the right-hand corner. From measurement of the distance of the observer from the window, and the height of the window, Dr. Heis was enabled to calculate two points in the path of the Meteor.

We may sum up, in a few words, the conclusions at which the author arrived from a careful comparison of the various observations which reached him. He believes that the fire-ball first became visible at a point in the North Sea, about 53° 50′ north latitude, and longitude 5° east of Greenwich, at a height of 88 miles; that it travelled from north to south, and disappeared in latitude 51° 28′, longitude 5° 18′, at a height of 17 miles, having in its visible course traversed 187 miles in 4½ seconds, at the rate of 47½ miles in a second. The path inclined towards the horizon, at an angle of 22°.

We have said that the author himself believed that the fire-ball had fallen to the earth. So convinced was he of this, that he made a journey to the place near which he supposed it to have fallen, in order to search for and make inquiries after it. He wandered over the neighbourhood of Herzogenbusch, in the north of Flanders, for several days, but without success, and departed at last, disappointed indeed, yet still hopeful, for he left at the village schools a promise of a large reward for any boy who should find a meteoric-stone.

On all sides, however, he found the impression existed that the Meteor had fallen in the immediate neigbourhood, and from the interval of time which elapsed between the disappearance of the light and the observation of the sound in this vicinity, he calculated the height at which it exploded. But unfortunately the ideas of the Belgian peasants as to length of the interval were rather vague. Several guessed it at five minutes, which was much too long, so the Doctor, in his perplexity, appealed to an intelligent cook, who both saw the Meteor and was frightened by the noise. In answer to the question, "Could she have boiled an egg hard in the interval?" she replied, "Lord bless me, no—not even soft!—Lord bless me, no; it could not have done in double the time;" and so the interval was reduced from five minutes to less than one minute, which was further diminished by other observers to twenty-two or twenty-five seconds.

If it were solid, and had fallen entire, there would hardly have been much difficulty in finding the object, for Dr. Heis has calculated that in such a case the earth would suddenly have acquired a mountain as large as one of the Siebengebirge. The diameter of the fire-ball he estimates at 1,381 English feet; but it may be, he remarks, that these bodies have only a small nucleus within a luminous envelope.

The cosmical relations of the fire-ball of the 4th of March we must dismiss very briefly. The author determined that it moved around the sun in a hyperbola, and that it became visible at a point in the heavens near the star γ Cephei. For the elements of this determination we must refer the reader to the little work under review.

With regard to the chemical composition of fire-balls, Dr. Heis has nothing new to tell us. The recent discovery of hydrocarbons, graphite, and free sulphur in stones which have fallen, may lead to the supposition that some are wholly combustible in very attenuated air, and we may thus account for the phenomena of falling or shooting-stars; while in others the mineral matters may predominate, and these sometimes exploding with detonation, fragments fall to the earth constituting meteoric stones.

Respecting the origin and destination of the Meteors and fire-balls we have, of course, no information, and the votaries of modern science and of ancient poetry will still continue variously to regard them as fresh fuel for our flaming sun, or fragments of a shattered world.

MILLS AND MILLWORK.*

To the minds of laymen the vocation of engineering is not so obviously cut up into distinct departments as the better known and older professions. While time and the experience which each of us must encounter teach all men to distinguish, with some approach to accuracy, between the many distinct provinces into which the practice of medicine and that of law are divided, there are comparatively few persons not connected with engineering who are aware that the same division of labour which characterizes each of the three so-called learned professions may be found to regulate and aid the labours of the engineer. The two main lines of the calling are pretty well known under their relative names of Civil, and Mechanical Engineering; but out of these, and especially out of the latter, there spring numerous entirely distinct branch lines, each leading and ministering to its own special industry, and each (to carry out our figure) presided over by a distinct staff of management with widely different functions.

The civil engineers being a more purely professional class than their mechanical brethren, naturally deal with a wide range of matters, and do not greatly tend to split up into specialities; but the mechanician being generally a practical man who lives by producing as well as scheming machinery, soon finds that his business, to be made profitable, must be confined within comparatively narrow limits.

Hence there arises an immense variety of machine makers, all included under the generic title of mechanical engineers, a body amongst whom, taken as a whole, there exists an astonishing amount of practical experience and theoretical knowledge; but each having his own speciality out of which it is seldom his wish or his interest to travel.

This is, however, quite a recent state of things in the profession.

* 'Mills and Millwork.' By W. Fairbairn, Esq., C.E., LL.D., F.R.S., F.G.S., &c. 2 vols. Longmans.

Some fifty years ago, when the machinist's art was in its infancy, the "millwright," who may fairly be considered as the ancestor of mechanical engineers, was far from special in his pursuits. In the best cases he was, to use Mr. Fairbairn's own words, "the sole representative of mechanical art. He was the engineer of the district in which he lived; a kind of Jack-of-all-trades who could with equal facility work at the lathe, the anvil, or the carpenter's bench. Generally he was a fair arithmetician, knew something of geometry, levelling, and mensuration, and, in some cases, possessed a very competent knowledge of practical mathematics. He could calculate the velocities, strength, and power of machines; could draw in plan and section, and could construct buildings, conduits, or water-courses in all the forms and under all the conditions required in his professional practice; he could build bridges, cut canals, and perform a variety of work now done by civil engineers. Such was the character and condition of the men who designed and carried out most of the mechanical work of this country up to the middle and end of the last century."

In the course of the great modern expansion of the mechanical arts, the old millwright has become very nearly extinct, and the wide field in which he laboured has been partitioned among several craftsmen. The domain of mill-work is, however, still very comprehensive, while it is not surpassed in importance by any other branch of mechanical industry.

Mill-work may properly be said to include every engineering process involved in the construction both of the buildings and machinery employed in producing consumable manufactures, including every species of motive power, whether derived from wind, water, or steam. Mr. Fairbairn's book is a practical and, in some particulars, an exhaustive treatise on each of these subjects, which are judiciously divided into five sections, comprising—1. Introduction, with a sketch of the early history of mills. 2. The principles of mechanism. 3. On prime movers. 4. On the machinery of transmission. 5. On the arrangement of mills. Of the two first sections we have little to say; both might have been omitted without detriment to the merits of the work; it is only after we have skimmed the curious information of the first, and glanced at the familiar elementary mechanics of the second section, that we begin to find the great storehouse of the author's original experiences open, or to recognize what an enormous amount and variety of actual practice is here reduced, tabulated, and made ready for the daily use of the millwright and engineer.

Throughout the whole of his work, but especially in the second and latest published volume with which we have more particularly to deal, Mr. Fairbairn is essentially "practical." It is a noteworthy fact that in spite of the aid which mathematical science affords to the engineer, our best machinists and our best machinery are less the result of applied mathematical investigation than of intuitive judgment backed by the time-honoured rule of thumb. It is true that the mathematician's aid is in every-day use in ascertaining the direction and intensity of strains and calculating the resisting powers of the various parts of machinery, but even through all the elaborate tables and rules given by our author for the determination of the proportions of gearing, shafts, or any other portion of mill work, the fact transpires, that the mathematics have been fitted to the practice, and not the practice to the mathematics. Nor is this peculiar to Mr. Fairbairn; on the contrary, a similar tendency has pervaded the work of our best engineers, so that it has almost come to be believed by some, that a great mathematical capacity is inconsistent with unusual mechanical ability.

Though this is a question of much interest, we do not propose to discuss it here, but merely remark, in passing, that Mr. Fairbairn's work is certainly another and weighty argument put into the mouths of those who hold that the great masters in the mechanical craft have ever used pure mathematics as a very humble kind of servant, treating her mainly as a *custos rerum*, or a means of making the results of their great natural intuition and observation common property for their inferiors or successors.

The second and recently published volume of the work opens with Section 4, and contains an elaborate investigation into the wide subject of the machinery of transmission. Amongst one of the most important general conclusions on this subject, towards which Mr. Fairbairn conducts the reader, is that of the superiority of toothed gearing over straps or other wrapping connectors for purposes of transmission. It is well to have our attention called to this point at a time when the example of American engineers has produced a strong feeling in favour of strapping as compared with gear, and Mr. Fairbairn does good service in pointing out the superiority of wheelwork. The advantages which can be claimed for straps are smoothness of motion, noiselessness of action, and perhaps smallness of first cost; but they are cumbrous, frequently out of repair, destructive in their effects on the journals, and wholly inapplicable in cases where the motion requires to be transmitted in a constant ratio. One of the drawbacks to a freer use of toothed wheels has hitherto been found in the great expense of truly shaped and fitted gears; but the introduction of the wheel-moulding machine, with its consequent improvement in the truth of teeth in cast-wheels, is likely to bring wheelwork into more extensive use than at present.

The chapters on the teeth of wheels would be little more than a recapitulation of the ordinary mathematical demonstration of their true form were it not for the introduction of a most useful series of practical tables, from one or other of which, as if from a ready reckoner, every problem concerning any required wheel may be instantly solved, whether it relate to the strength, pitch, thickness, depth, clearance, or horses' power to be transmitted through a particular tooth.*

* Among the drawings given of various forms of teeth is one which, like the table just referred to, illustrates the very practical nature of this treatise. Our mechanical readers are, of course, aware that in most demonstrations of the Epicycloidal tooth that particular form having its flanks formed by hypocycloids, which are also radial lines, is almost exclusively dealt with. Now this is a tooth which, notwithstanding the simplicity of its delineation, is rarely used in practice, because of its inherent weakness; so, although we get, as usual, some prominence given in the demonstration to the radial hypocycloid, Mr. Fairbairn's practical bent does not permit him to leave his reader without giving a figure of the "teeth of a large wheel, traced from one of my own patterns, to exhibit the form which practice has

The remaining chapters on the machinery of transmission deal chiefly with shafting and its details. Next to the practice of dividing labour into minute departments, and making each man's work a task of repetition, the factory system depends for its economy of production on the concentration of a large number of machines under one building. Some years ago, before this plan was carried to its present extent, it was common in mills to have separate water-wheels to every machine; but, as trade developed, the true principle of concentrating the motive power soon forced itself into notice. No sooner did it become the custom to use either one large water-wheel or steam-engine to drive the whole factory, than the question of shafting for the transmission of power to the distant parts of the building began naturally to receive attention. In order to show to what an extent this system of transmission has been carried, we may mention that, at the great Saltaire Mills, more than two miles of shafting is employed. Nowhere, perhaps, throughout his work, does Mr. Fairbairn give more full, accurate, and useful information in a tabulated form than on the subject of shafting, while the practical examples of couplings, clutches, journals, and brackets, illustrated by detail drawings, comprise every modern design of value.

Section 5, on the arrangement of mills, opens with some very interesting remarks and information on mill architecture. It is true that Mr. Fairbairn does not touch at all upon that frequently agitated question, the shortcomings of the engineer as an architect, but his sketches and observations tend to bring it closely before us. A recent writer very well remarked, in speaking of the relations between the engineer and the architect, that, in consequence of the entirely opposite views which either of the two take of their respective professions, the "architects are quarrelling over Greek mouldings and Gothic pinnacles, and dreaming of *reproducing* the elegance of classical times, while the engineers are spanning our rivers with structures such as the world never saw before, arching under our mountains, and roofing acres for stations. They are, in fact executing a series of works which throw everything else hitherto done into the shade; but all this, unfortunately, without that touch of higher art which is alone wanted for perfection, and this simply because the building profession is divided against itself, because its two branches are conducted on principles so much at variance that they cannot work together. The engineers cannot forego theirs, because they are the only principles which men of sense can follow; so unless the architects will consent to waive some of their archæological fancies, we may be condemned to live in the midst of ugliness for ever. When once this fact is appreciated, we shall surpass all preceding ages in architec-

shown to be desirable." In this specimen, as might have been expected, the flanks of the teeth are generated by a small describing circle, whose hypocycloid gives a tooth admirably proportioned and amply strong in the root. This is a small matter, perhaps, but not an unimportant one. No young student of mechanical engineering is likely to be led astray by Mr. Fairbairn, and the teeth of the wheel, "traced from my own pattern," are a good sample of the principle on which the whole of the book is written.

ture as we have done in engineering. To call architecture back within the domain of common sense is what is most wanted on the part of the engineers to complete the services they have rendered and are rendering to mankind."

Whether brought about by architects or engineers, there is, however, a great change for the better in the artistic treatment of mill buildings. Mr. Fairbairn gives us a sketch of a very slight attempt at architectural effect with which he succeeded, in 1826, in replacing the old boxlike form of mill, and there is no doubt that much of the credit of modern improvement in this respect is due to him. There is still room, however, for the advent of that architect of the future alluded to by the writer from whom we have quoted above.

Among the most interesting descriptions of mills actually erected by our author which occupy the larger and latter half of his second volume is the Taganrog Corn Mill, on the north shore of the Black Sea, constructed for the Russian Government, and originally intended for the double purpose of supplying the Russian navy with biscuit, and facilitating the export of Russian grain in the shape of flour. The terms of the Paris treaty of peace, stipulating that no vessel of war should be retained on the Black Sea, have modified the original objects contemplated in the erection of these mills, and they are now used only for the purpose of grinding, dressing, &c. The mill contains 36 pairs of stones arranged on Mr. Fairbairn's longitudinal principle, and possesses every requisite for grinding 180 to 200 bushels of wheat per hour.

During the siege of Sebastopol it was determined by the English Government to supply the troops daily with fresh flour from the grain of the surrounding country, and the description of the 'Bruiser' floating mill and bakery is one of the most generally interesting in the book. This vessel was fitted up internally precisely in the same manner as an ordinary mill, the power being derived from her screw engines. Without the sketches it is difficult to extract an intelligible description of the floating mill, but we learn that, "During the time the vessel was in Balaclava harbour, the daily produce of flour was about 24,000 lbs. It was originally intended that the mill should be capable of producing 20,000 lbs. of bread per day, but it proved equal to a considerably larger production. The total quantity of bread turned out in the three months from January to March, 1856, was 1,284,747 lbs., and the expenses of working were 2,017*l.* or 3*s.* 2*d.* per 100 lbs. of bread made. The quantity of flour ground in the same time was 1,331,792 lbs., with 358,172 lbs. of bran; the expenses of working were 2,050*l.*, or 3*s.* 1*d.* per 100 lbs. of flour produced. The total cost of the flour produced was about 25*s.* 3*d.* per 100 lbs., the wheat costing about 18*s.* per 100 lbs. The grinding of the wheat was found to be performed quite satisfactorily while the vessel was at sea, even in a heavy swell causing an excessive motion."

Bearing in mind the success of this experiment and the importance of fresh flour and bread to the health of troops, Mr. Fairbairn suggests the propriety of "a light portable steam-engine and mill for grinding being constantly attached to the camp whenever an army takes the field. The whole affair would not exceed the weight of one of our heavy siege-guns, and there would be no practical difficulty in the way of introducing an engine capable of supplying newly-baked bread from an oven constructed in the smoke-box of a portable locomotive engine, mounted on wheels and prepared to grind at the same time." Here is another direction in which the ingenuity of mechanicians may be made to serve the interests of military practice, somewhat more peaceable than that which is leading many of our best mechanical engineers to become either artillerists or armourmakers.

Our limits do not permit us to follow Mr. Fairbairn through the descriptions of flax, cotton, oil, gunpowder, and paper mills, all of which are more than usually valuable, as they contain, in almost every case, the story of his own doings, and the result of his own practice. As the most successful and most extensive master-millwright in the world, Mr. Fairbairn has done good service to the profession of engineering by the publication of this work. The subject is one on which there has been a singular dearth of published information; most other important branches of engineering have been treated at length by more or less able authors, but the mysteries of the millwright's craft have been hitherto preserved mainly in oral traditions and empirical rules. No fitter person than Mr. Fairbairn could have been found to give this floating information a shape. Commencing his work as a millwright some fifty years ago, he found the practice of mill-work in a most primitive condition. By the application of new principles, by the concentration of motive power, the substitution of cast-iron wheelwork for the old and cumbrous forms of wooden gear, the improvement of water-wheels by the invention of ventilating buckets, the use of the steam-engine as a prime mover, and last, not least, the introduction of wrought-iron shafting of small diameter, he brought about just such a revolution in the millwright's art as the increasing commercial activity of his time demanded. Like most men who attain celebrity, William Fairbairn has worked hand in hand with circumstances. His professional career commenced, to use his own words, "just at a time when the country was recovering from the effects of a long and disastrous war, and he was enabled, from this circumstance, to grow up with, and follow out conscientiously, nearly the whole of the discoveries, improvements, and changes that have since taken place in mechanical science." Hence it was that he was enabled to apply his great natural mechanical abilities with so much success towards the further development of our industrial resources and the extension of our trade throughout the globe.

LOCAL FLORAS.*

The highest attainment of Natural-History science is to describe accurately the living inhabitants of the earth. This can only be done by the slow and laborious process of making catalogues of the plants and animals of particular localities. Such catalogues are of little use to those ignorant of natural-history studies, and can only be compiled by those who have made the greatest progress, and are competent critically to pronounce that the forms alleged to have been found in a particular locality are truly the forms named by some standard authority. It is no wonder then, that so little has been done towards giving an exact account of the animals and plants of any particular district. Of all parts of the world, the British Islands afford the best opportunity for such a study, and perhaps there is no country where so much has been done in this direction. The work is, however, still very imperfect. Our lists of animals and plants, such as are comprehended in our Floras and Faunas, do not pretend to give the localities, excepting generally where any particular species has been found to occur. The relation which a local Flora bears to a general Flora, is well seen in Professor Babington's 'Manual of the British Flora,' and his list of plants in the 'Flora of Cambridgeshire.' In the one, the species of plants are given which occur throughout Great Britain, and the locality is only generally stated by the county or district in which it grows; in the other, every locality in which a particular plant is known to occur, is given.

It is only when plants and animals are studied in the last-mentioned way, that the causes of their growth and distribution can be expected to be discovered. It is evident to all who pass through a limited or large space of country, that the growth of plants is very varied, and no one can fail to be impressed with the fact, that there are certain causes acting which produce this great variety of distribution. A cursory examination shows that such influences as temperature, moisture, water, and composition of soil are at work, and general laws can be laid down according to which certain groups of plants are found to flourish or disappear. It is, however, as we come to examine individual species, that we find no explanation can be given of their absence and abundance; and closer observation of the connection between each species and the soil, and other conditions of their growth, are demanded for the purposes of satisfactorily affording the basis of the laws of their distribution. Much has been done in this direction, and we are indebted to the laborious efforts of Mr. H. C. Watson, to reduce to something like general order what is at present known of the distribution of English plants.

Apart, however, from the scientific interest that attaches to the

* 'Flora of Surrey; or, a Catalogue of the Flowering Plants and Trees found in the County.' By James Alexander Brewer. London: J. Van Voorst.

'Flora of Marlborough; with Notices of the Birds and a Sketch of the Geological Features of the Neighbourhood.' London: J. Van Voorst.

accurate description of plants in particular localities, they have their value in directing the attention of students to places where they can find species which otherwise would escape their attention. It is perhaps to this fact that we are indebted for the publication of local Floras as separate works at all. The publication of such works has been especially called for and produced by the formation of local Naturalists' Field Clubs. These Associations, devoting themselves to the exploration of the natural history of the localities in which they occur, collect a great quantity of information, and it is to such a Society that the public is indebted for one of the Floras named at the commencement of this article.

We are also indebted to other Clubs in various parts of this county for similar works. Nothing can be more conducive to health, both of mind and body, than such Associations, and a public is thus formed capable of appreciating and using Local Floras such as those above mentioned.

It is also very desirable, when the study of Natural History is cultivated in schools and families, that guides to the treasures which are to be found in the immediate neighbourhood should be possessed by the pupils as incentives to the collection of particular or rare kinds of natural-history objects.

It is a mistake to suppose that natural objects can only be successfully studied in their larger or more striking forms; it is the objects which are found at every man's door that become the field for the grandest and most important discoveries. Lyonnet has made for himself an undying reputation by the study of the anatomy of the caterpillar of the common privet hawk moth. Huber studied the bees in his own garden and the immediate neighbourhood of his residence. White has made Selbourne a classical spot for all time by the study of the habits of the animals within a mile of his own house. The finest illustrations of his beautiful theory of the origin of species were derived by Darwin, not from his studies as a naturalist who had voyaged round the world, but as a country gentleman who had studied the habits of the tenements of his dovecote, and the relations of the cats, mice, bees, and clovers in his own paddock. Fascinating as the prospect must be to every young and ardent lover of nature to traverse the ocean, and view its wonders under tropical suns, or piercing the rich forests of the torrid zones, to behold for the first time with human eyes, the forms of animal and vegetable life they may contain, there is nothing more certain than that the fixed and quiet study of natural objects at home can be made as rich a source of intellectual pleasure, and important discovery, as traversing distant, though more fertile fields.

It is with much pleasure, then, that we direct attention to two works which have been recently published on Local Natural History. They are both called 'Floras,' at the same time they are both something more than a mere catalogue of plants and their localities. In both we are supplied with maps of the district, to the elucidation of the botany of which they are devoted. In both we have a sketch of the geology of the part of the country in which the plants are found, a recognition of the relations of the plants to the soil in which they grow, of considerable importance. To the 'Flora' of Marlborough there is also added a list of birds found in the neighbourhood of that place. We should be glad to see the practice of combining lists of plants and animals followed up so that every student of natural history may be supplied with a knowledge of whatever forms of life exist around him, in whatever direction his particular tastes may lead him.

Of the two works before us the most unpretending is the 'Flora of Marlborough.' It is the production of Mr. T. A. Preston, who is too modest to place his name upon the title-page, but he dates from Marlborough College. He says, in his preface, the work was "undertaken mainly for the purpose of assisting those members of the College who may be fond of Botany." We are sure all friends of a more extended education than is at present afforded in our great educational establishments, will congratulate Marlborough College on the production within its walls of this contribution to Local Natural History. We do not know whether any direct encouragement is given to the study of Natural History at Marlborough, but we regard this publication as one of many other indications that natural science is beginning to excite attention, and its claims to a place in the curriculum of school studies recognized.

In the list of plants presented by Mr. Preston he confines himself to the limit of a circle with a radius of six miles from Marlborough. This circle is divided into four districts, and lies principally upon the chalk formation, so that little opportunity is given for the comparison of plants occurring on different geological strata.

The arrangement of plants followed is that of Professor Babington, in the fourth edition of his 'Manual of British Botany.' The author has done this from the conviction that, although Bentham's 'Hand Book' is extremely useful for those beginning the study of Botany, and has many excellent points about it, yet the wholesale manner in which Bentham has united what have generally been regarded as distinct species, and described them imperfectly, as varieties, have induced him to prefer Babington's book.

The list of plants is preceded by some remarks on the 'Geological Features of Marlborough,' by W. G. Adams, Esq. This essay is devoted to the description of too small a portion of the earth's surface to call for criticism, but it is evidently the production of one who has studied the geology of the district, and contains an interesting exposition of the causes that have been at work in the production of the chalk, and the beds that lie above it in the neighbourhood of Marlborough. We may, however, venture to say that we think the Diatomaceous theory of the production of flints in the chalk, as propounded by Mr. Adams, is hardly borne out by the facts of the case. Whether the silex of flints was once in the form of the skeletons of Diatoms is perhaps a question, but we have no knowledge of any facts which could lead to the conclusion that flints are produced as the result of a conglomeration of the skeletons of Diatoms.

Of the list of plants we have nothing further to say than that it is printed on the plan of Professor Babington's 'Flora of Cambridge,' and that for every locality given for a plant the initials of the name of the observer are attached.

The list of birds has been drawn up by R. B. Smith, Esq., of Corpus Christi College, Oxford. The notes attached to the name of each bird are interesting, and will be found to make this part of the work much easier reading than the list of plants. It would not perhaps be found impossible in Local Floras to make notes to the plants which might be instructive to the beginner in Botany.

The Flora of Surrey is much the most important volume of the two. It is three times the size of the last; has two valuable coloured maps; embraces the plants of a county; has a history; and has been produced by men not unknown to fame. Who that has studied Natural History the last quarter of a century, is not acquainted with the papers of "Rusticus, of Godalming?" It was the late J. D. Salmon, of Godalming, with a few friends interested in the study of plants, who first resolved, at a meeting held in the town of Guildford, to procure materials for the publication of a Flora of the county of Surrey. Mr. Salmon undertook the task of editing this Flora, and had proceeded to some considerable extent with his task when he died. At the sale of his effects, in the autumn of 1861, all his MSS., and a rich collection of plants which he had formed, were purchased by the Holmesdale Natural History Club, and those materials were placed in the hands of the author of the 'Flora of Reigate,' for publication. No one could be better fitted for the work, and Mr. Brewer has now produced a Flora which, for accuracy and extent, stands unrivalled amongst the Local Floras of Great Britain.

As already stated, this work is accompanied with two maps; on one of them the county is divided into nine divisions, to each of which a letter is attached. Each plant is referred to in the list, as it is found in one or other of these divisions. The second is a geological map, which has been drawn and coloured from one laid down by Mr. Joseph Prestwich. The work opens with an Introduction on the Physical Geography and Botanical Divisions of the county of Surrey, which, we are informed, was written by the late J. D. Salmon. It is an interesting geological and geographical account of the county of Surrey.

The list of plants is very copious, and the arrangement and nomenclature generally adopted are those of the fifth edition of the 'London Catalogue of British Plants.' We should have preferred the plan of following some British Manual, and in this respect we think the plan of the Marlborough Flora the best. The notices of localities are very numerous, and the names of the specimens are at once guarantees of the accuracy of the observations.

The most interesting parts of the volume to the general student will be found in the Appendices, of which there are four. In the first is given a list of plants introduced to the country, and *not* thoroughly naturalized. The second contains a list of plants found on the Thames side, near Wandsworth and Battersea, and which are undoubtedly introduced plants from seed brought to this locality by the presence of a large distillery situated at the waterside. They nevertheless have their interest in showing how plants from distant counties may be introduced and become naturalized. The third Appendix consists of a table showing the geological distribution of plants in the county. From this table we gather that the number of plants known to occur on all strata is 117. The number confined to the valley alluvium, 7; to the superficial gravels, 19; to the Bagshot sands, 9; to the London clay, 14; to the Reading and Woolwich beds, 2; to the chalk, 55; to the upper greensand and gault, 5; and to the lower greensand, 28. The last Appendix gives the relative proportion of the plants of the United Kingdom to those enumerated in the Surrey Flora, and also the proportion which the number of species in each natural order in Surrey bears to the total amount in the country. From this table we find that Surrey is deficient in the following natural orders:—*Frankeniaceæ*, *Tamariscaceæ*, *Illecebraceæ*, *Plumbaginaceæ*, *Eleeagnaceæ*, *Aristolochiaceæ*, *Empetraceæ*, and *Eriocauloneæ*. It will at once be seen that none of these are common orders.

The Flora of Surrey contains altogether 984 species, besides 65 well-marked varieties. The following five plants are believed to be peculiar to Surrey. *Impatiens fulva*, *Teucrium Botrys*, *Lilium Martagon*, *Digitalis sanguinalis*, and *Buxus sempervirens*. The latter, the common Box, is well known throughout England, but is not thoroughly naturalized in any other county.

From what we have said, it must be seen that the Flora of Surrey is a most valuable and laborious work, and deserves to be in the hands not only of every lover of Natural History in the county of Surrey, but in those of every student of Botany throughout the country. We are glad to observe a good list of subscribers, and wish that our good opinion of the work may be the means of increasing its sale, and encouraging Local Natural History societies to follow the good example of the Holmesdale Natural History Club.

NOTES AND CORRESPONDENCE.

On the Highest Magnifying Power of the Microscope yet employed.

In giving a very brief summary of my recent observations upon the mode of termination of the nerves in voluntary muscle, the editor of 'Cosmos,' for August 28th, 1863, remarks:—"Nous regrettons pour notre compte que M. Beale n'ait pas dit dans sa note avec quel genre d'oculaires et avec quel jeu de lentilles il a pu obtenir le prodigieux grossissement de 3,000 fois."

I propose in the present short communication to describe briefly how my drawings representing objects magnified to this extent were obtained. In making drawings of microscopical objects, it is usual to represent the image the size it appears when thrown upon paper with the aid of the camera or neutral tint glass reflector at the distance of 10 inches from the eye, the arbitrary point at which the magnifying power of object-glasses is measured. If the image be taken at a point nearer to the eye it appears smaller; while, at a greater distance, it of course appears much larger than at the arbitrary distance above stated. Large diagrams may indeed be made *direct from the microscope*, by placing the diagram paper at the distance of 3 feet or more from the eye, and tracing upon it with a long pencil the object as reflected from the neutral tint glass reflector.

In practice, I have often found it almost impossible to represent, in drawings, lines as fine as those seen in the preparation. A certain coarseness is inevitable. The copied lines and markings appear rougher and thicker than the real ones. But this defect is to some extent removed by drawing the object somewhat larger than it appears to be magnified at the distance of 10 inches from the eye; and, in order to obtain uniform results, I always draw the object the size it would appear if copied on the same level as the stage of the microscope. The scale for measurement is copied at precisely the same distance. A glass which at 10 inches is said to magnify 200 diameters will magnify 215, and my high power, which was made for me two years since by Messrs. Powell and Lealand, instead of magnifying about 1,600 diameters, increases the image of the object to 1,800 diameters. By increasing the length of the tube of the microscope between 4 and 5 inches, I obtain an amplification amounting to 3,000 diameters, and the $\frac{1}{1000}$ of an English inch becomes 3 inches in length.

With care in illumination, I have been able to see points in an object magnified with this power which I had failed to observe under a power of 2,000. It seems to me probable that I may succeed in increasing the power to 5,000 diameters; and with this object I am trying different plans, the results of which shall be recorded shortly. The common paraffin lamp gives a very white and good light for working with these high magnifying powers. I have tried the lime light, but have as yet reaped no advantages from its use.

So far I have certainly obtained better results by increasing the length of the tube of the microscope than by increasing the magnifying power of the eyepiece, which accords with the results of some experiments performed many years ago by Dr. Carpenter. Of course, the practical utility of increasing the magnifying power entirely depends upon the character of the specimen. Into the question of preparing specimens I must not, however, now enter, further than to say that my specimens are immersed in the strongest glycerine that can be procured. I never represent a structure more highly magnified than is necessary to bring out the points; but I find that, with an improved method of preparation, I desire higher magnifying powers; and I am quite certain that great advantages will be reaped when powers far higher than any yet made or thought of shall be brought to bear upon many structures. The question of preparation is scarcely more than a mechanical one, and new and more exact means of preparation will soon follow improvements in the optical part of the microscope.

It should be stated that many specimens of muscular fibre, nerve fibres, nerve cells, &c., have been prepared, so that they can be magnified 3,000 diameters, and points can be made out (as, for example, what appears a single fibre can be resolved into several) which cannot be seen, or, at any rate, have not been observed, by an ordinary magnifying power.

The object-glass I have employed is the first twenty-sixth made for me by Messrs. Powell and Lealand, which is a most excellent working glass. That it defines exceedingly well, and admits plenty of light, is obvious from the fact that it will allow of the tube being increased in length. By a working glass I mean one that can be employed without trouble or difficulty, and does not require any elaborate arrangements with regard to illumination, adjustment, &c. In fact, I use it without even a condenser, employing only the common concave mirror. There is plenty of room for focussing, although, of course, specially thin glass or mica must be employed. I have made and published many drawings of tissues of the higher animals magnified with this glass, and it need scarcely be said, that as it can be brought to bear upon textures of this class (even bone and teeth), thin sections of which are obtained only with great difficulty, it must be readily applicable to other departments of microscopical inquiry.

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Scientific Education and Natural-History Science in the Kingdom of Italy.

Genoa, *Nov.* 18, 1863.

The state of science and scientific education in Italy at the present moment, when this country is on the point of emergence from political nonentity, and is beginning to feel that it is one of the great powers of Europe, possesses peculiar interest, and may well justify a few remarks in an English journal established to record the progress of science.

Itself the birthplace of many departments of human knowledge, as well as of many of those men who have been most distinguished in science as well as art, Italy still contains, or has only very recently lost, men of European reputation in Physics, in Astronomy, in Geology, in Zoology, and in Botany; and though some of the most eminent of those now living have been diverted from their ordinary pursuits by the pressing claims of political events, and the absolute necessity that all true men should unite in securing the one great object of nationality and unity, there is abundant proof of healthy activity which in due season may be expected to yield great results.

The Universities of Italy have gradually become lowered in general reputation, owing to the extreme facility afforded to very young men to pass examinations and obtain diplomas. Each seat of education has outbid its fellows in this respect till the result has become very serious, and a great effort is now being made to raise the standard of education throughout the country. The University of Pisa, always among the most celebrated, has especially recommended itself to observation for its efforts in this direction. At first the natural result was to frighten away so many students as to reduce the numbers very greatly; but already it is found that the degree there conferred is much more valuable, and that it is worth while to take the additional trouble to pass. To Professor Matteucci, whose researches in electricity and general physics, are as well known in England as in Italy and France, much of the credit of this is due. M. Matteucci has now left Pisa, and is established at Turin, where he has already occupied for some time the important post of Minister of Public Instruction. It is not unlikely that he may again be appointed, and it would seem that a more fit appointment could not be made.

One of the latest improvements in Public Instruction has been the foundation of a normal school at Pisa, on the footing of the upper normal schools of France, but with the object of securing a really well-informed class of schoolmasters for the education of all classes throughout Italy. Of this establishment, Professor Villari, the able author of the 'Life of Savaronola,' recently translated into English by Mr. L. Horner, is the director, and he is assisted by an excellent staff of professors in all departments. During the last academical year, the number of students was only about 20, but the entries for the year now commencing (November, 1863) are already much more numerous. Several of the students have passed their University examinations with honour, and are admitted to the normal school at the public expense. Others pay a sum of 80 francs (3*l.* 4*s.*) per month during their residence. All reside in the building, and dine together as in an English college. The system adopted partakes both of the professorial system as carried out in Germany, and of the tutorial system common at Oxford and Cambridge.

The public museums both at Pisa and Florence, are admirable. Both are particularly rich in wax preparations, illustrative of Comparative Anatomy and Botany. The former is also rich in geological specimens. The various minerals and rocks of Tuscany, and the fossils of the Valley of the Arno are especially interesting, not only to the general traveller, but to the technical geologist; for Italy is beyond all other countries in Europe that one in which the phenomena of metamorphism can best be studied. The neighbourhood of Pisa, with the country a little to the south towards Volterra, affords indeed the best key to the very difficult and complicated changes that have affected rocks of almost all kinds within periods of very various duration. In this part of the world, mineral character is no guide to the age of rocks, and fossils, though they exist and have proved extremely valuable in skilful hands, are so exceedingly rare and imperfect, that no traveller however acute, who trusted to his own observation, could hope to do much with them in a rapid journey. The labours of Professor Paolo Savi and Professor Meneghini have greatly tended to simplify and explain the matter, and assisted by the memoir and very admirable maps just prepared for publication by Professor Savi, no one need now waste his time. The memoir in question is, however, published in a volume on the general statistics of the district, and is not altogether accessible.

It is not generally known that this small corner of Italy around Pisa contains a tolerably complete series of formations. There are old palæozic schists greatly altered, but recognizable, overlaid by carboniferous rocks, in which anthracite represents the coal. Over these altered rocks is a good representation of the trias, and the lower lias is seen in those wonderful beds of statuary and other marble that are so well known and highly esteemed. Above these, are jurassic rocks, and above these again neacomian sandstones, while the chalk is seen in the *Alberese*, a peculiar limestone sometimes approaching marble in colour, but not saccharoidal. Tertiaries of all ages abound in Tuscany, from the lowest nummulitic rocks to the most recent gravels.

Tuscany abounds also in metals. With Elba close at hand, it may be supposed that there is no lack of iron. Copper ore, the purest and most valuable known, is found at Monte Catini, and in one or two other spots. At Monte Catini, the results have for the last 20 years proved as profitable as the deposit is remarkable. The copper ore is found in kidney-shaped lumps of sulphide of copper, mixed irregularly in a paste of soft, moist serpentinous material. The pockets containing the ore are sometimes large, but in the highest degree irregular. The lode is a kind of vein in the altered volcanic rock of Tuscany, called *gabro rosso*, a singular mass of angular and rounded material. Magnesia has played a very important part in all the changes and modifications that have taken place in it. To the presence of magnesia is due, among other things, the beautiful green marble called serpentine, of which there are so many varieties in Tuscany; and although the serpentine rock of the Lizard in Cornwall is of very different appearance and hardness, the presence of the same mineral causes the peculiarities of both.

Lead ore also is found in Tuscany, and deposits of some importance are worked in various places. The lead contains silver. Other metals (mercury among the number) are not wanting, and there seems a prospect of the metalliferous deposits of Italy soon becoming even more worked than in the days of ancient Rome, when its produce exceeded that of any country known at that time.

But the working of the marble quarries must always be one of the most important departments of mineral industry in northern Italy. No one who has not visited Italy can imagine the vast development of this industry. In Genoa—the city of palaces—rightly called the superb, marble of the most beautiful kind and excellent quality, of endless variety in colour and texture, is almost the only material used for construction. Marble staircases, marble balustrades, marble pediments, and marble floors are seen in every hotel, and even in every private house. The churches are marble inside and out, the public buildings are of the same material. In the streets, on the piers, and above all, in the *Campo Santo* or Cemetery, wherever we may go, the marble is displayed in abundance. The same, to some extent, is the case at Milan, at Pisa, and in most of the other cities remarkable for architectural beauty or interesting in history. The geologist in such a country, and under such circumstances, is sure to find abundant matter for inquiry. The marvellous abundance of marble is the result of change or metamorphic action on various beds of limestone. These changes have originated in the volcanic and other igneous causes traceable everywhere in this part of the world. Active volcanoes, in the south extinct, but perfect volcanic craters in the centre, and occasional earthquakes in the north of Italy, are or were the cause of the eruptions of sulphurous and other gases, and of hot aqueous vapours loaded with mineral matter. These are common almost everywhere, and it is these that have converted the limestones into marble, the clays into shales, and the sands into quartzite. Whether we take the veined and coloured marbles where the impurities or foreign ingredients still remain, or the true white and statuary marble where the foreign substances only occupy small veinicles, or *madri macchei*, as they are here called, the general history is the same, and metamorphosis is the only cause to which we can reasonably refer.

In other departments of natural history, Italy — especially in the northern and central provinces—is not only rich, but is well represented in the principal museums. It is chiefly, however, in the preparations illustrating the comparative anatomy and physiology, both of animals and vegetables, that the extraordinary accuracy, ingenuity, and patience of the Italians can be best appreciated. These are truly wonderful, and they are quite without rival in Europe. Highly magnified representations of the developement of a plant from the seed, a winged insect from the grub, or a chicken from the egg, are not unknown elsewhere, but at Florence and Pisa there is a profusion of illustrations truly marvellous.

However we may consider the question, we shall find that the recent political changes in this part of the world are already bearing abundant fruit, in the liberation of the human intellect from the slavery that had so long weighed upon it. To say that there are great differences of opinion, and that many persons even regret the old régime, is only to say in another way that the country is free. Everyone may and does safely and loudly express his own view of the government, and all proposed changes are freely discussed. It does not follow that the best measures are at once adopted, but this healthy and free discussion will certainly ensure the greatest ultimate good, while education and science in all departments will not fail in securing their due share of attention when the excitement of politics has a little calmed down. The acuteness of Italian intellect, and the elegance epually characteristic of this people, have still a great part to perform in the history of science.

D. T. Ansted, F.R.S.

Dahomey: its People and Customs.

Whydah, *Sept.* 2, 1863.

Here I am, on my return from Kana, where I was received by the King of Dahomey during the celebration of the "little customs;" and I will now send you some information concerning this country.

Whydah, or Ajudah, is the port of the kingdom, though about two miles distant from the coast. It has 8,000 or 10,000 inhabitants, governed by a "yanogan," who is, in his turn, ruled over by one of the princes of Dahomey. The inhabitants are robust, well formed—I might almost say handsome—with the exception of the head, which wants intelligence: that superior mark which the Creator appears to have denied to the negro race. There is, however, a wide difference between the morals of this people and those further to the south. Nothing is to be seen here calculated to shock the eyes of a civilized man, nor anything objectionable to his ordinary habits. Nay, I can say more; there is positively in the Dahomeyans a sense of personal dignity. Unfortunately, one encounters at every step traces of that Fetischism which arrests all progress, and transforms a man naturally gentle into a brute beast. The principal deities worshipped by this people are—Lightning, or Fire of Heaven; the Boa, or Python; the Lion, the Tiger, and the Vampires.

I visited the Temple of Serpents in this town, where thirty of these monstrous deities were asleep in various attitudes. Each day, at sunset, a priest brings them a certain number of sheep, goats, fowls, &c., which are slaughtered in the temple, and then divided amongst the "gods." Subsequently, during the night, they spread themselves about the town, entering the houses in various quarters in search of further offerings. It is forbidden, under penalty of death, to kill, wound, or even to strike one of these sacred serpents, or any other of the same species; and only the priests possess the privilege of taking hold of them for the purpose of reinstating them in the temple should they be found elsewhere.

When a house is struck by lightning, the master is obliged to pay a heavy tribute to the priests of the "Fire of Heaven;" for such an event is always regarded as the denunciation of a great culprit. Should a man be struck by lightning, his body is cut in pieces, and sold by the priests to the populace, who devour this roasted flesh! The dwelling of the dead man is then pillaged and razed to the ground; and the Fetisch worshippers immolate victims on its site, in order to appease the anger of the "Fire of Heaven."

The Vampires may be found on trees in the vicinity of the Temple of Serpents; there they are collected by millions, and after sunset they disperse through the gardens and over the surrounding country.

On leaving Whydah for the interior, the traveller at once observes that the land rises gradually through a succession of upheaved plateaux or downs, which run parallel to the sea from east to west, the surface soil being to a great extent intermixed with small rolled flints.

The utmost elevation which I found between Whydah and Kana was 500 English feet, and that was at a village called Havy (? Havee), about halfway between the two towns. Although Kana is lower than this point, it is quite apparent that further towards the north the land again rises to such a degree, that the capital, Abomey, situated ten miles north-east of Kana, must be elevated to about the same height as Havy. From the information that I have obtained in various quarters concerning the interior, there must be a range of mountains about three days' journey north of Abomey. However, this is a question on which I hope shortly to have ocular evidence.

The King received me cordially; but, in order to reach the palace, I had to pass several scaffolds, bearing the corpses of victims who had been immolated on the previous evening. Some were suspended by the feet, others were upright. During twenty days these horrible spectacles were renewed, with a few decapitations in the interval.

Consul Burton was more fortunate than I, for he only arrived at Kana two or three days before the King departed for the war, and after the conclusion of the sacrifices. It is a difficult matter to predict what Europe may gain from this king and his advisers. I believe, however, that if the abolition of the slave-trade be conceded (the very seat and centre of which is at this place —Whydah), there is a happier future in store for this land.

It is with the view to obtain this concession that I am on the eve of my departure with your brave Commodore Willmot, and we shall soon have a definite reply. If it be favourable, my journey of exploration will be suspended; otherwise, I shall at once proceed northward. The concession of the abolition of the slave-trade in the kingdom of Dahomey is the more to be desired, inasmuch as it would put a stop to the depopulation of a country of undoubted fertility and natural wealth, and which is eminently adapted for the cultivation of cotton.

If the King grants the abolition, he would be all the more ready to encourage the growth of that staple, in order to give employment to his people, who would then no longer be compelled to engage in war for the purpose of making prisoners, to be sold as slaves.

This is a succinct account of my hasty impressions of Dahomey; receive it as such as I am able to communicate.

Jules Gerard.

THE GOLD MEDALLISTS OF THE SCIENCE AND ART DEPARTMENT OF THE COMMITTEE OF COUNCIL ON EDUCATION.

It affords us great pleasure to give publicity to the names of those Students who succeeded in obtaining Gold Medals in Science at the Examination held by the above Department of the State last May in London and the provinces.

Group I. *Geometry, Mechanical Drawing, and Building Construction.*

Student's Name.	Age.	School or Residence.	Occupation.	Name of Teacher.
Rowden, William T.	23	*Trade School, Bristol.*	*Science Teacher.*	*Self-taught.*

Group. II. *Theoretical and Applied Mechanics.*
No Gold Medal awarded.

Group III. *Experimental Physics.*

Doherty, Joshua	26	180, Agnes-street, Belfast.	National Teacher.	Eardley, F.

Group IV. *Chemistry Inorganic and Organic.*

Googan, Richard	21	North Main-street, Bandon.	Geologist.	Hofmann, Dr., and Dowling, J.
O'Sullivan, Cornelius	21	South Main-street, Bandon.	Geologist.	Hofmann, Dr., and Dowling, J.

Note.—Mr. O'Sullivan was *very* nearly equal to Mr. Googan, and having taken the Silver Medal last year he could not receive it again. He has therefore, under the exceptional circumstances, been awarded a Special Prize of Books of the value of 3*l.*

Group V. *Geology and Mineralogy.*
No Gold Medal awarded.

Group VI. *Animal Physiology and Zoology.*

Wilson, George	25	12, Stanley-street, Pimlico, London.	Student of Science.	Self-taught.

Group VII. *Vegetable Physiology and Systematic Botany.*

Wilson, George	25	12, Stanley-street, Pimlico, London,	Student of Science.	Self-taught.

Group VIII. *Mining and Metallurgy.*
No Gold Medal awarded.

The first-named of these Students (Mr. Rowden) received only a Certificate, as he does not belong to the Classes entitled to receive Medals. The following is the Government Regulation concerning the Medals generally:—" The Queen's Medals which are offered for competition throughout the United Kingdom at the General Examination of Science Schools and Classes held each year in May consist of one Gold Medal for each group of subjects, and one Silver and two Bronze for each subject. All persons wherever taught may compete, the only restriction being that the Medals cannot be taken by Middle Class Students who are more than seventeen years of age. Middle Class Students above seventeen years of age who would otherwise have taken the Medal receive an Honorary Certificate instead."

Books received for Review.

From *Messrs. Blackwood & Sons*:—

PHYSICAL GEOGRAPHY (Introductory Text-Book of). By David Page, F.R.S.E., F.G.S., &c. 193 pp. 1863.

From *Messrs. John Churchill & Sons*:—

QUALITATIVE CHEMICAL ANALYSIS (A System of Instruction in). By Dr. C. R. Fresenius, Professor of Chemistry, Wiesbaden. Edited by J. Lloyd Bullock, F.C.S. 6th English Edition. 360 pp. Coloured Plate of Spectrum Analysis. 1863.

TOPICS OF THE DAY (Medical, Social, and Scientific). By James Ansley Hingeston, M.R.C.S., L.S.A. 400 pp. 1863.

From *Messrs. Longman & Co.*:—

MANUAL OF THE METALLOIDS. By James Apjohn, M.D., F.R.S., M.R.I.A., Professor of Chemistry in the University of Dublin. 600 pp. 1863. (One of Galbraith & Haughton's Scientific Manuals.)

From *Mr. Lovell Reeve*:—

DICTIONARY OF NATURAL HISTORY TERMS WITH THEIR DERIVATIONS: including the various Orders, Genera, and Species. By David H. McNicoll, M.D., M.R.C.P. 590 pp. 1863.

From *Mr. Van Voorst*:—

FLORA OF MARLBOROUGH, with notices of the Birds, and a sketch of the Geological Features of the Neighbourhood, with a Map. 153 pp.

FLORA OF SURREY; or, a Catalogue of the Flowering Plants and Ferns found in the County, with the Localities of the Rarer Species. From the Manuscripts of the late J. D. Salmon, F.L.S., and from other sources. Compiled for the Holmesdale Natural History Club, Reigate. By James Alexander Brewer. 391 pp.

THE FIRST PRINCIPLES OF NATURAL PHILOSOPHY. By William Thynne Lynn, B.A. Lond., F.R.A.S., of the Royal Observatory, Greenwich. 100 pp.

From *the Editor*:—

THE IBIS. A Magazine of General Ornithology. Edited by P. L. Sclater, M.A., Ph.D., F.R.S., Sec. Z.S., F.L.S., &c., &c. Vol. IV. 1862. 392 pp., with 13 coloured Lithographs. (N. Trübner & Co.)

From *the Authors*:—

OPHTHALMOSCOPIC SURGERY (A Manual of), being a Practical Treatise on the Use of the Ophthalmoscope, &c. By Jabez Hogg, F.L.S, &c., &c. 3rd edition. Numerous Chromo-lithographs. 296 pp. (J. Churchill & Sons.) 1863.

HEAT IN ITS RELATIONS TO WATER AND STEAM. By Charles Wye Williams, A.I.C.E. 2nd edition. 220 pp. (Longman & Co.) 1861.

OBSERVATIONAL ASTRONOMY, and Guide to the Use of the Telescope. By a Clergyman. Edited by J. T. Slugg. 96 pp. (Simpkin & Co.) 1862.

THE STARS AND THE TELESCOPE. By J. T. Slugg. (Simpkin & Co.) 1862.

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ORIGINAL ARTICLES.

THE MAMMALS OF MADAGASCAR.

By P. L. Sclater, M.A., Ph.D., F.R.S., Secretary of the Zoological Society of London.

Organic beings are not scattered broadcast over the earth's surface without regularity or arrangement, as the casual observer might suppose, nor are they distributed according to the variations of climate or of any other physical external agent, although the latter have, unquestionably, much influence in modifying their forms. But each species (or assemblage of similar individuals), whether of the animal or vegetable kingdom, is found to occupy a certain definite and continuous geographical area on the earth. In like manner, each genus, or assemblage of species, each family, or assemblage of genera, and each order, or assemblage of families, may be said to be subject to similar laws, as regards its geographical distribution,—although, as might have been supposed, the areas occupied by the higher groups are usually larger, and in some cases co-extensive with the earth's surface.

It thus happens that the various parts of the world are characterized by possessing special groups of animals and vegetables, and that, as a general rule, such tracts of land as are most nearly contiguous have their Faunæ and Floræ most nearly resembling one another; while, *vice versâ*, those that are farthest asunder are inhabited by most different forms of animal and vegetable life. When any exception to this rule occurs, and two adjacent lands possess dissimilar forms, or two regions far apart exhibit similar forms, it is the task of the student of geographical distribution to give some reason why this has come about, and so to make the "exception prove the rule."

In the present paper I propose to devote a short space to the examination of one of the best known and strangest of these anomalies in geographical distribution—namely, that presented to us by the Fauna of the Island of Madagascar. Madagascar being immediately contiguous to the eastern coast of Africa, and separated from it by a channel in one place only some 200 miles across, in which, moreover, there are several intermediate islands, while it is very far removed from India and America, ought, according to generally-received rules, to exhibit a Fauna of a purely African type. But this, as is well known to naturalists, is not the case. The numerous Mammals of the orders Ruminantia, Pachydermata, and Proboscidea, so characteristic of the Æthiopian Fauna, are entirely absent from Madagascar. The same is the case with the larger species of Carnivora, which are found throughout the African continent, but do not extend into Madagascar. Again, the highly-organized types of Quadrumana, which prevail in the forests of the mainland, are utterly wanting in the neighbouring island, their place being there occupied by several genera of the inferior family of *Lemurs*. In the like manner, I shall be able to show that similar irregularities prevail to a greater or lesser extent in every other part of the series of Mammals, and that, in short, the anomalies presented to us by the forms of life prevalent in this island are so striking, that claims have been put forward in its favour to be considered as a distinct primary geographical region of the earth.*

But let us take the Orders of Mammalia as they are generally recognized, one by one, in order that we may examine more carefully the affinities of each genus of them included in the list of Madagascarian Mammals. To do this, it will be most convenient to refer to the catalogue of the Vertebrates of Madagascar lately published by M. François Pollen, in the 'Nederlandsch Tijdschrift voor de Dierkunde;' † this being the only general article bearing upon the subject that has yet appeared. M. Pollen's list is a compilation for his own use, as being about to visit Madagascar, of what has been recorded by previous authorities on the subject. Amongst such authorities, the most important, as regards Mammals, is certainly an article by M. Victor Sganzin, in the third volume of the 'Memoirs of the Society of the Museum of Natural History of Strasburg.' M. Sganzin was the commandant of the French settlement of Sainte-Marie, on the north-east coast of Madagascar, in 1831 and 1832, and obtained on that island and on the adjoining coast of Madagascar proofs of the existence of about a hundred Vertebrate animals, concerning which he gives us notes, without, however, in many cases, any precise determination of the species. Long before his time, it is true, De Flacourt and Sonnerat

* The most natural primary divisions of the earth as regards Zoology are, as has been shown in the 'Journal of Proceedings of the Linnean Society' (Zoology), ii. p. 130, and elsewhere, (1) The *Neotropical* region, comprising South America, Mexico, and the West Indies; (2) The *Nearctic*, including the rest of America; (3) The *Palæarctic*, composed of Europe, Africa north of the Sahara, and Northern Asia; (4) The *Æthiopian*, which contains the rest of Africa, Arabia, and Madagascar; (5) The *Indian*, consisting of Southern Asia and the western half of the Malay Archipelago; and (6) The *Australian*, which comprises the eastern portion of the Malay Archipelago, Australia, and the Pacific Islands.

† 'Nederlandsch Tijdschrift voor de Dierkunde,' Amsterdam, 1863, vol. i. p. 277.

had published narratives of their voyages to Madagascar, and the latter had made known to science several of the most remarkable types of the island;* but neither of these explorers has furnished any general indications as to the character of its Mammalian Fauna. In 1833, three French naturalists — Bernier, Goudot, and Rousseau — visited Madagascar, and it is to the labours of these energetic collectors on the eastern coast, and to those of Dr. W. Peters, of Berlin, on the western coast, that science is chiefly indebted for the progress that has lately been made towards the compilation of a list of the Mammals of this island, which, however, as far as our present knowledge extends, only embraces some 49 species—namely, Quadrumana 28, Carnivora 5, Chiroptera 5, Rodentia 1, Insectivora 9, Pachydermata 1.

To begin then with the order Quadrumana, the most remarkable and most characteristic type of Madagascarian Mammals here presents itself at once at the head of the list. The Lemurs are universally recognized among naturalists as forming a separate and distinct group of Quadrumanous Mammals. And of the Lemurs nearly thirty different species, embracing eight generic forms, are found in Madagascar, whilst all Africa only contains some eleven or twelve species of these animals, and the Indian region not more than three. This will be better seen by the subjoined table, in which the distribution of the genera of the family of Lemurs and the approximate number of the known species of each genus are given—

Table of the Distribution of the Lemuridæ.

Sub-family.	AFRICA.	MADAGASCAR.	ASIA.
Indrisinæ		1. Indris (2) †	
		2. Propithecus (1)	
		3. Avahis (1)	
Lemurinæ		4. Lemur (16)	
		5. Hapalemur (2)	
		6. Lepilemur (1)	
		7. Chirogaleus (2)	
	8. Perodicticus (2)		
			9. Nycticebus (2)
			10. Loris (1)
Galaginæ		11. Microcebus (2)	
	12. Galago (9)		
Tarsiinæ			13. Tarsius (1)

Moreover, as the whole number of Mammals at present known to exist in Madagascar does not amount to fifty, we have this very remark-

* De Flacourt's 'Histoire de la Grande Ile de Madagascar,' and Sonnerat's 'Voyage aux Indes Orientales.'

† *N.B.*—The numbers in figures placed after the generic names in the table give the (in some cases approximate) number of species of the genus. Until very recently but one species of *Indris* was known to science; but M. Vinson has lately discovered, and described in the 'Annales des Sciences Naturelles' (Zool. xix. p. 253), a second from the forest of Alanamazoatrao—which he has proposed to call *Indris albus*.

able fact—quite unparalleled, as far as is hitherto known, in any other Fauna—that nearly two-thirds of the whole number of known species of the Mammals of this island are members of one peculiar group of Quadrumana.

Again, when we come to examine the *Lemuridæ* of Madagascar, and to compare them with their brethren in Africa and India, we find that they present us with no less than eight different generic types—all distinct from those found in the two latter countries.

The genera *Indris*, *Propithecus*, and *Avahis* constitute a section of *Lemuridæ* per se, easily distinguished from the rest of the family by having only five molar teeth on each side of the jaw, and only two (instead of four) inferior incisors. No genus with this form of dentition is found either in Africa or Asia. The true *Lemurinæ* are also most fully developed in Madagascar, the typical genus *Lemur* being numerous in species, and, as is stated by travellers, likewise in individuals. In Africa this sub-family is represented by the abnormal form *Perodicticus*—a recently-discovered second species of which is likewise considered by Dr. Gray* as entitled to generic rank. In India two allied genera of Lemurinæ are found—*Nycticebus* and *Loris*—likewise difficult to connect satisfactorily with the more typical members of the group, but presenting many indications of alliance to *Perodicticus*.

The third sub-family of the Lemuridæ is essentially African—consisting of the genus *Galago*, with eight or nine species dispersed over various parts of that continent, while *Microcebus*, with two or three imperfectly-known species, takes its place in Madagascar.

The next form we meet with as we descend the series of Madagascar Mammals, is the celebrated Aye-aye (*Chiromys Madagascariensis*), an animal so anomalous in its structure, that although it has been now conclusively proved that its nearest allies are amongst the Lemurs,† even the illustrious Cuvier referred it to the widely-distant order of Rodents. The Aye-aye is pronounced by Professor Owen to be more nearly allied to some of the African Galagos than to any other living form. It may be, however, remarked that the Tarsier of the Indian Archipelago (*Tarsius spectrum*) presents certain points in its structure which likewise show a remote affinity to this extraordinary type.

The second order of Mammals—the Bats or Chiroptera, have, as far as our present knowledge goes, only five representatives in Madagascar. Two of these belong to the Frugivorous family *Pteropodidæ*—and curiously enough to the *Indian*, not to the African section of the group. One of them indeed (*P. Edwardsii*) is so clearly allied to the common *Pt. medius* of continental India, as to have been very constantly confounded with it. ‡

The three known species of insectivorous Bats of Madagascar (*Rhinolophus Commersonii*, *Vespertilio Madagascariensis* and *Emballonura*

* See Dr. Gray's 'Revision of the Species of Lemurian Animals.' Proc. Zool. Soc. 1863, p. 129.

† See Prof. Owen's Memoir 'On the Aye-aye.' Trans. Zool. Soc. v. pt. 2 (1863).

‡ As to the real distinctness of these species, see Peters, 'Zool. Reise n. Mossambique,' vol. i. p. 22.

Madagascariensis) supply us with no very precise indications as to their geographical affinities.

In the next order of Mammals the *Insectivora*, of which nine species are known to inhabit Madagascar, we again find a very peculiar group of types, consisting of the genera *Centetes*, *Ericulus*, and *Echinogale*. These little animals, though generally associated with the Hedge-hogs (*Erinaceus*), to which in their external appearance they present much resemblance, have been recently declared by Dr. Peters—who has devoted much attention to the *Insectivora*—to be most nearly allied to the American genus *Solenodon !* * So to find their nearest affines we have to cross the whole (present) continent of Africa and the Atlantic Ocean to the West Indian Islands, where the only two known species of *Solenodon* occur.

Besides the *Centetinæ* the Insectivora of Madagascar consist of two species of Shrew (*Sorex*)—a form widely distributed in the Old, and northern portion of the New World, and a singular little animal, at present very imperfectly known, which was described by M. Doyère in 1835 under the name of *Eupleres Goudoti*. The *Eupleres Goudoti* is stated to agree in its dentition with the moles (*Talpa*), to which genus also it would likewise seem to present some resemblance in its habits; but its general external conformation is much more like that of a small vermiform Carnivore, and its describer considers it to constitute the type of a new family of *Insectivora*, leading off towards the Carnivora.

The order Carnivora again presents us with three types peculiar to the island—*Cryptoprocta*, *Galidia* and *Galidictis*. These, however, all belong to the family *Viverrinæ*—a group peculiar to the Old World, and of which several allied genera inhabit the adjoining parts of Africa. It is not, therefore, necessary to look "across the Atlantic" for the nearest relatives to the Madagascarian Carnivora. Strangely enough, the nearly universally distributed types *Felis* and *Canis* seem utterly unrepresented in this Fauna.

Of Rodents only one species, I believe, has yet been registered as found in Madagascar. This is a squirrel of the genus *Sciurus*—which, as far as it is known, exhibits African affinities. Rats and mice, indeed, there are in Madagascar, as in nearly every other habitable portion of the globe where man has penetrated, but these are of the well-known European species, and must be put into the same category as the cats, dogs, and oxen which have been introduced into and flourish in the island.

The important order of Ruminants, which is so greatly developed on the opposite coast of Africa, appear to be wholly wanting in the indigenous Fauna of Madagascar. While Antelopes of numerous species abound in every part, whether plain or forest, of the adjoining continent, and the Giraffe and Buffalo are likewise everywhere characteristic features of the Æthiopian Mammal-fauna, not one of those creatures is known to occur in Madagascar, and this fact alone would serve to

* Cf. Peters, 'Ueber die Saügethier-gattung, *Solenodon*.' Abh. Acad. Berlin, 1863.

mark out the wide difference between these two creations as they stand at present. The same is nearly the case as regards the next order—that of Pachyderms. The *Hippopotamus*, so abundant on the opposite coast of Mozambique, is not found in Madagascar. Had Madagascar ever formed part of Africa this would hardly have been the case. The genus *Equus*, well represented in Southern Africa by the Zebras and Quaggas, the Hyrax and the Rhinoceros, is likewise wanting; and of the Artiodactyles only a single species—namely, the South African Riverhog (*Potamochœrus Africanus*)—is stated to inhabit Madagascar. But although M. Sganzin has positively identified this species as a Madagascarian animal, I cannot but think it rather doubtful; in the first place, because this is the *only* exception to the general rule of specific (and almost generic) difference between the Mammals of Madagascar and Africa; and secondly, because Dr. Peters tells us he could obtain no indications of the existence of this Pig upon the opposite coast of Mozambique. However, until the contrary is proved, it is only fair to assume M. Sganzin's statement to be correct, and to include this Riverhog in the list of Madagascarian Mammals.

Having thus given a cursory view of some of the more salient features of the Mammal-creation of Madagascar let us see what deductions we can gather from them as to its origin—taking, of course, for granted, the derivative hypothesis of the origin of species—at present, the only theory by which the otherwise inexplicable facts of geographical distribution can be explained. Of course it would be more satisfactory in a case like the present to have before us a summary of the knowledge we possess concerning every part of the Fauna and Flora of Madagascar, but as space does not permit this, let us see what we can make out from the Mammals alone.

The following deductions may, perhaps, be arrived at from what we have before us:—

1. Madagascar has never been connected with Africa, *as it at present exists*. This would seem probable from the absence of certain all-pervading Æthiopian types in Madagascar, such as *Antilope*, *Hippopotamus*, *Felis*, &c. But, on the other hand, the presence of Lemurs in Africa renders it certain that Africa, as it at present exists, contains land that once formed part of Madagascar.

2. Madagascar and the Mascarene Islands (which are universally acknowledged to belong to the same category) must have remained for a long epoch separated from every other part of the globe, in order to have acquired the many peculiarities now exhibited in their Mammal-fauna—*e.g.* *Lemur*, *Chiromys*, *Eupleres*, *Centetes*, &c.—to be elaborated by the gradual modification of pre-existing forms.

3. Some land-connection must have existed in former ages between Madagascar and India, whereon the original stock, whence the present Lemuridæ of Africa, Madagascar, and India are descended, flourished.

4. It must be likewise allowed that some sort of connection must also have existed between Madagascar and land which now forms part of the New World—in order to permit the derivation of the *Cente-*

tinæ from a common stock with the *Solenodon*,* and to account for the fact that the Lemuridæ, as a body, are certainly more nearly allied to the weaker forms of American monkeys than to any of the Simiidæ of the Old World.

To conclude, therefore, granted the hypothesis of the derivative origin of species, the anomalies of the Mammal-fauna of Madagascar can best be explained by supposing that, anterior to the existence of Africa in its present shape, a large continent occupied parts of the Atlantic and Indian Ocean stretching out towards (what is now) America on the west, and to India and its islands on the east; that this continent was broken up into islands, of which some became amalgamated with the present continent of Africa, and some possibly with what is now Asia—and that in Madagascar and the Mascarene Islands we have existing relics of this great continent, for which as the original focus of the "*Stirps Lemurum*," I should propose the name Lemuria!

EXPLANATION OF THE PLATE.

The accompanying sketch by Mr. Wolf will serve to illustrate the more remarkable types of the Mammal-kind of Madagascar. On the summit of the trees are Lemurs of different species (*Lemur leucomystax*, *L. varius*, *L. catta*, and *L. xanthomystax*). In the centre is the Aye-aye; on the ground to the right is one of the remarkable Carnivores of the island (*Galidictis vittata*) staring at it; on the left is the little *Echinogale telfairi*, endeavouring to make its escape from such an extraordinary assemblage. In the background may be seen the celebrated Traveller's-tree (*Urania speciosa*), and other marked forms of Madagascarian vegetation.

ON THE SOLAR SPOTS.

By SIR JOHN F. W. HERSCHEL, Bart., K.H., D.C.L., F.R.S.

THE physical constitution of the sun, and the nature of the source from which its expenditure of light and heat is supplied, must be regarded as by far the most important astronomical problem which remains unresolved, connected as it is not only with the maintenance of all animated existence, but as a matter of speculative interest with every branch of physical science; since there is not one which has not to be laid under contribution in support or confutation of the various theories which have been, and will probably be henceforward, proposed to account for it. Apart from the knowledge of the dimensions and mean density of the sun which we derive from the great fact of planetary Astronomy, from its presumed connection with the Zodiacal light, and from the appendages to its disc, which become visible in total eclipses, and which demonstrate the existence of a solar atmosphere extending to a vast distance beyond the general

* This single case, it must be reasonably allowed, would be hardly sufficient for the foundation of so startling a supposition; but the presence in Madagascar of American forms of Serpents (*Xiphosoma*, *Heterodon*, *Philodryas*, and *Leptodeira*), of Iguanoid Lizards, and even of American Insects, necessitates some such hypothesis.

luminous surface or *photosphere*, we have little or nothing to guide us in this inquiry but the telescopic examination of its surface, which reveals to us, besides a general texture of a very peculiar kind, the existence of dark spots, temporary in their duration, holding no fixed position with respect to its poles and equator, and presenting, in other respects, no analogy to those appearances on the planets which indicate the existence of local peculiarities on their solid globes, or of conditions in their atmosphere as to clouds and clear sky which obtain in our own. These spots, ever since their complete and recognized discovery *as such* by Fabricius, Galileo, and Scheiner, in 1611 (for though occasionally seen before the invention of the telescope, they had hitherto been taken for Mercury or Venus in inferior conjunction), have always been examined with great though desultory interest: and it is only since the year 1843, when Schwabe announced his important discovery of the periodicity of their occurrence, that the desirableness of keeping up an unbroken record, *a complete diary*, in fact, of the appearances presented by the solar disc, supplying by observations in different places the lacunæ left by cloudy weather in any one, has been recognized.

During the years antecedent to this epoch, however, a vast amount of interesting information had been gathered as to their dimensions and forms, their *penumbræ* and *umbræ* (or, as they were sometimes called, nuclei,) the *faculæ* or veins of brighter light which accompany and surround them, or which exist detached and remote from spots; their law of distribution over the surface; their generation, duration, and extinction; their appearances, disappearances, and reappearances, as carried round with the globe of the sun by its rotation on its axis, &c: all particulars very necessary to be borne in mind in reference to their physical explanation, as well as to what may be called their descriptive history, and of which a brief *résumé* may not be thought irrelevant as introductory to the more especial subject of this notice, which is intended to draw attention to the conclusions which may be deduced from certain recent observations of their movements in longitude and latitude in reference to the equator of the sun's globe.

But, first, we have a few words to say on the conditions requisite for viewing the sun with effect, and for delineating or photographing its spots, which will not be thought out of place by many of that numerous class of observers who, with telescopes or other apparatus competent to do good service, are without much experience in this special line of observation. A very convenient mode of viewing them is by projecting the image of the sun in a darkened room, on a white screen. This, in its rudest form, was the method followed by Kepler, who used only a small hole in a shutter, without a lens, and was thus enabled to see a spot on November 29, 1606, and another on May 18, 1607 (o. s.), which he also took for Mercury (then, however, not in transit, and not even in inferior conjunction). If a lens be used to bring the rays to a focus, the image, of course, is much improved. Still more if it be achromatic: and if in place of a single lens a good telescope of moderate focal length be used, and the eye-piece drawn out somewhat beyond the focus for parallel rays, an image of a high degree of perfection is procured, which may be impressed photographically or delineated manually. The former is the mode practised at the Kew Observatory by Mr. De La Rue, and we believe by most other helio-photographers: the latter is understood to be the origin of those exquisite drawings laid before the Royal Astronomical Society by Mr. Howlitt. One improvement only seems yet wanting to render either of these modes of procedure as satisfactory as actual vision through the telescope—*viz.* in the place of the ordinary telescopic eye-piece to substitute an achromatic and aplanatic object-glass of *short focus* and sufficiently large aperture, having the radii of the surfaces of its two lenses calculated on the principles laid down in my paper ('Phil. Trans.,' 1821) for the construction of such an object-glass. The radii so calculated afford a lens, aplanatic not merely for parallel rays, but for all distances of the radiant point, so that when inverted, or placed with its flint lens towards the light, and used as a microscope, it produces *neither colour nor spherical aberration*, and is thus excellently fitted for projecting a magnified image, perfect not only as to the form, but as to the *colour*, of the spots, and on a scale of any desired enlargement, by a mere change of focus and corresponding alteration of the screen's distance.

When the telescope is used *as* a telescope, the great brightness and intense heat of the sun require to be subdued, to make observation possible. It is a common mistake to suppose that this can be done by merely contracting the aperture of the object-glass by a circular diaphragm placed before it. In practice this is fatal to distinct vision. *Cœteris paribus*, in telescopic vision, the sharpness of definition is in the direct ratio of the angle (within moderate limits) which the object-glass subtends at its focus. Any attempt to evade this law by stopping out the light by concentric *annuli* will be found to issue in worse confusion. To use the full aperture of the telescope is of paramount necessity either in viewing the sun or planets. If the extinction of the light is effected by coloured glasses, the best combinations I have yet found are: 1st, that of two plane glasses of a shade between brown and violet, with one of a grass-green hue interposed: or 2nd, of two green glasses, with a blue one coloured by cobalt between them. These allow scarcely any rays of the spectrum to pass but the yellow and less refrangible green; and they cut off almost all the heat. The *perfection* of vision is attained by using only the extreme red rays; but glasses which transmit these cannot be used on account of the heat they allow to pass. Whatever combination of glasses be used, they are, however, apt to crack and fly to pieces through the heat which they *do* intercept. Hence the necessity of either limiting the field of view by a metal screen with a small hole *in the focus* of the object-glass, as recommended for trial by Wilson, in 1774, and as practised with excellent effect by Mr. Dawes; or of some construction of the telescope itself, which, in the act of forming the image, shall suppress a very large percentage of the whole incident light, without preference of colour. Such is the object of the "Helioscope" described in my "Cape Observations," *

* (1847), page 436.

which utilizes for the formation of the image only about one 900th part of the incident rays, and if a greater diminution be desired, it may be obtained by a polarizing eye-piece. I have reason to believe that this construction will ere long receive a full and satisfactory trial at the hands of one of our most distinguished solar observers and practical mechanists. In default of a glass-reflecting speculum such as this construction requires, and of the prism recommended for a second reflexion, I have used (*vide locum citatum*) a plane glass, roughened at the back, interposed obliquely, so as to intercept the converging rays before forming the first image, and reflect them through the eye-piece of a Newtonian telescope with great advantage. Mr. Hodgson* has recommended, and used successfully, a similar contrivance, with a refracting one.

Spots on the sun have frequently been seen with the naked eye, by taking advantage of its proximity to the horizon, or of the intervention of light clouds. Instances of the kind are recorded by the annalists before the invention of telescopes—in A.D. 807 and 1160; and since by Galileo himself, by D'Arquier (April 15, 1764; January 30, 1767; June 6, 1763), by Sir William Herschel (April 17, 1779, September 2, 1792), &c. Only the bare existence of a spot, however, can be so discerned. No details of course can be distinguished. When viewed with telescopes, the spots are seen to consist of two very broadly distinguished shades of darkness: that of the interior and smaller portions, or *umbræ*, being so dark as to be called in common parlance black (considerably less so, however, than the body of Mercury or Venus seen in transit, or the moon during a solar eclipse); the exterior and larger (which usually, but not always, completely surrounds the *umbra*) of what would be termed in painting a half-shade, and therefore called the *penumbra*. Occasionally, but rarely in large spots, this is altogether absent. But whenever it exists the line of demarcation between the shades is sharp and unequivocal. So, at least, I have invariably found it, and whenever a gradation of tint from one to the other has been thought to have been perceived by other observers, I am disposed to attribute it to the optical mixture of the images of the ragged edges of the penumbra with the black ground on which they are projected on the retina arising from imperfect definition. The point is of extreme importance in the physical theory of the spots. So marked a distinction is altogether adverse to the idea of a luminous gas or fluid, indefinitely miscible with, or soluble in, a non-luminous transparent atmosphere; while it agrees with that of an aggregation of the luminous matter in masses of some considerable size, and some certain degree of consistency, suspended or floating *at a level determined by their specific gravity* in a non-luminous fluid; be it gas, vapour, liquid, or that intermediate state of gradual transition from liquid to vapour, which the experiments of Cagniard de la Tour have placed visibly before us; *and which, when we consider the high temperature throughout the solar atmosphere, and the enormous pressure at the surface of its solid globe (if it have any such) we cannot but believe to be realized on the grandest scale in solar physics.* And this is strongly corroborated by a certain streaky

* Royal Astronomical Society's Monthly Notices, Dec. 8, 1854.

or furrowed appearance in the penumbræ, directed always radially to or from the centre of the umbra, as if rifted, and allowing the black ground on which they are seen projected to appear through the chinks (see Fig. 3): an appearance likened in certain cases by Mr. Dawes to "bits of straw," and by Mr. Nasmyth asserted to be distinctly referable to certain fusiform, lanceolate, or "willow-leafed" objects of definite size and shape, superposed in general like scales, covering one another partially (see Fig. 5), but in the penumbræ, radially arranged, of which he conceives the whole luminous surface of the sun to consist.* It is not meant to assert that either the penumbræ or umbræ are devoid of all gradation of light. Both have darker and lighter shades, but (especially as regards the umbræ) within far narrower limits of variation. Within the latter, indeed, which, up to a recent period, most observers, after Sir William Herschel, had agreed to regard as openings through which the dark body of the solar globe could be seen, Mr. Dawes, by the application of his diaphragm eye-piece already mentioned, has disclosed the existence of a third, and still deeper *definite* shade of darkness, constituting, as it were, a nucleus, or umbra of the second order (see Fig. 3), to which we propose henceforward to restrict the name of "nucleus." Between the penumbra, too, and the general brightness of the photosphere, a suddenness of transition exists, less marked, indeed, than that between it and the nucleus, and less rigidly preserved, but yet on the whole exceedingly striking. And the whole series of phenomena strongly suggests the notion of three envelopes or veils between the exterior transparent atmosphere and the sun itself, the two outer being luminous, the inner probably only seen by reflected light;—each capable of being partially removed, either by some emanation or upsurging movement from below, or denudation from above, leaving a central opening, over which, when the denuding cause has ceased its action, the luminous strata tend to return, and spread themselves equally. Even in such central opening, however, the darkness is probably only relative, and, could the surrounding glare be completely extinguished, the light of the central space would probably equal or exceed that of the brighter incandescence of our furnaces. It is inconceivable indeed, that the actual surface of the solar globe (*if there be any such definite surface*), surrounded as it is by an *enceinte* of such a temperature as that of the photosphere, should be otherwise than in a state of the most vivid incandescence: and that it should appear no brighter than it does is not the least inexplicable feature of solar physics. Can it be that the interposition of mixed metallic vapours, each specifically opaque to definite rays of the spectrum between the body and the penumbral envelope may by their joint absorption, cut off nearly the whole of the light of the former? Ignited, transparent, and colourless liquids or gases, it should be observed, give off no light *from their interior*.

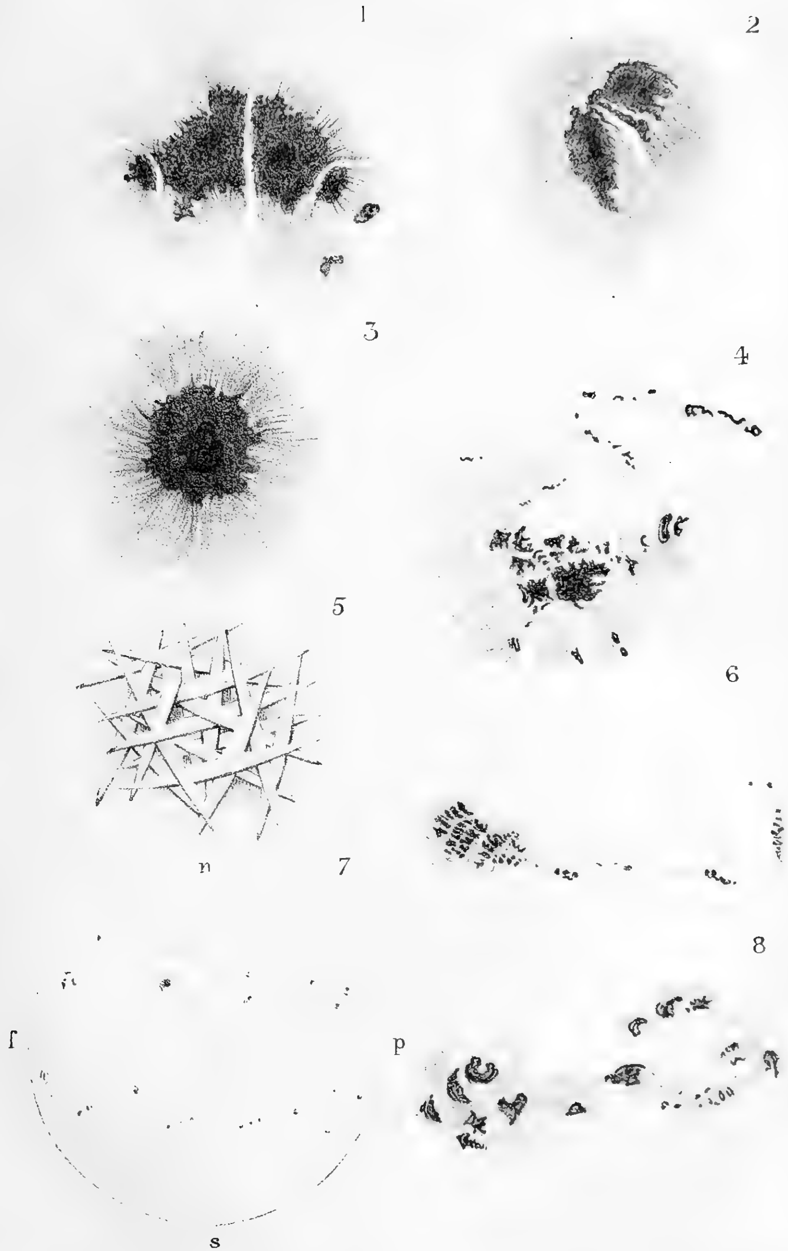
The forms of the spots are extremely irregular; of the penumbræ

* Other observers, as I have recently been informed, consider Mr. Nasmyth's "willow-leaf" figures as too slender and pointed, and liken the forms rather to that of rice-grains.

indeed excessively so. As there occur umbræ without penumbræ, so penumbræ occur without umbræ, but such are usually only branches or outlying portions of groups, or the remains of a spot in the act of obliteration when the umbra has disappeared. In the great majority of cases many umbræ are surrounded and connected into a group by a common penumbra. This indeed is almost always the case with large spots. The umbræ, when large, affect more compact and rounded forms than the penumbræ, and the interior *nuclei* of Mr. Dawes still more so. On the whole there is a certain tendency to the *bizarre* in all the forms, which though indescribable in words is highly characteristic. One of Mr. Howlitt's drawings offers a strange approximation to the complete form of a human skeleton. A form not uncommon, especially towards the subsidence of a period of solar activity, is that of a tadpole with a large irregular head consisting of a penumbra and several umbræ, and a curved penumbral tail dotted with smaller ones (see Figs. 4, 8). This form of spot has been noticed by some observers, among others by Picard in 1671, as recalling the outline of a scorpion (Fig. 6). The larger umbræ are often crossed (Fig. 1), or nearly crossed (Fig. 2), by narrow bridges of light, rarely penumbral, most usually of the full brilliancy of the photosphere, or even surpassing it. In many cases they are irregularly rounded on three sides, and sharply cut as if snipped by scissors on the fourth, and to such sharp edges there is often no penumbral border. Lastly, spots are much more commonly connected in groups than quite insulated, and very frequently affect linear sequences, oblique to the parallel of solar latitude in which they occur; the line of direction being towards a point in the sun's equator *preceding* the situation of the spot in longitude (see Fig. 7).

Large spots, or groups, are almost always attended by neighbouring *faculæ*, which are streaks, or vein-like appearances, more or less crooked and branching, of brighter light than the general photosphere. They are much more conspicuous, however, *near* the borders of the visible disc than towards its centre, a fact strongly indicative of their elevation, as ridges or heaps of the luminous matter, which so rising above the denser regions of the circumfused atmosphere, have their light proportionally less enfeebled by its absorption. On the other hand they are never traced fairly *up to* the actual edge of the disc—where the absorption of the solar atmosphere is so great as to extinguish (according to Chacornac) nearly half the light—a proof that their elevation is far from commensurate with the extent of that atmosphere, and that they are not identical with the "red flames" seen on the limb of the sun in total eclipses. Indeed the latter appear indiscriminately round every portion of the disc, whereas the faculæ are never seen in the sun's polar regions. Neither is the connection of the spots with faculæ one of reciprocity, for the latter are often seen where no spots exist.

When spots on the sun's surface are viewed from day to day, they are seen to undergo great changes in form, size, and relative situation *inter se*, as well as to be carried round by a common movement; evidently due to the sun's rotation on its axis in the same direction, and nearly in the same plane as that of the planetary movements; and



J W Herschel del.   Hanhart imp.

FIGURES FOR SIR J HERSCHEL'S PAPER ON THE SOLAR SPOTS

from this latter movement, by tracing the apparent paths of individual spots across the disc, the time of that rotation was early concluded, approximately by Galileo himself, and with more exactness by the use of micrometric measures by his successors—as well as the position of its axis in space, or, which comes to the same thing, the inclination of its equator to the ecliptic and the longitude of its ascending and descending nodes. As regards these latter particulars, the results arrived at by various observers and computists, especially the more modern ones (Lalande, Fixlmillner, Böhm, Laugier, and Carrington), are in as good accordance as could be expected, and may be stated at 7° 15′ for the inclination of the axis, and 73° 40′ for the longitude of the ascending node for 1850; so that the north pole of the sun's axis points nearly to the star π *Draconis,* and the south to α *Plutei.* As regards the time of rotation, however, the disagreement is more considerable, for a reason which will presently appear.

Few spots, and those only very large ones or groups of such, are permanent enough to be traced through more than one or two successive revolutions of the sun. Instances of three or four returns are extremely rare. Schwabe, however, in 1840, saw the same spot eight times in the middle of its course over the disc, having made seven full revolutions between May 11 and November 16. Single spots, or small groups, undergo such changes in a few days as to be hardly recognizable, and many originate and die out during a single transit. The origin of a spot when it can be observed, is usually traceable to some of those minute *pores*, or dots, which *stipple* the sun's surface, and which begin to increase, to assume an *umbral* blackness, and acquire a visible and at first very irregular and changeable shape. It is not till it has attained some measurable size that a penumbra begins to be formed, a circumstance strongly favouring the origination of the spot in a disturbance from below, upward;—*vice versâ,* as the spots decay, they become bridged across, the umbræ divide, diminish in size, and close up, leaving the penumbræ, which by degrees also contract and disappear. The evanescence of a spot is usually more gradual than its formation. According to Professor Peters and Mr. Carrington, neighbouring groups of spots show a tendency to recede from one another.

The changes undergone in a few hours by large spots, or among groups, are such as to alter visibly their shapes and relative situations, and from day to day to transform them entirely. Professor Wolf observed one on March 10, 1861, which in the short interval of 1h. 17m. underwent, not merely visible but enormous changes, altering its whole aspect. And when it is remembered that a single second on the sun's surface (seen from the earth) corresponds to 46. miles linear measure, and a square second (almost the *minimum visibile*) to upwards of 20,000 square miles, we need not to be told that such changes imply movements of a rapidity to which our fiercest hurricanes offer no approach; so that the term "viscous," which has been applied by some to the fluid in which the photosphere floats, is in the last degree inappropriate. Mr. Dawes and Mr. Birt have observed the umbræ of spots in some cases to rotate as it were slowly on their centres.

The earliest observers of the solar spots were led to notice the fact of their total absence in the circumpolar regions of the sun's surface, and we find it already remarked by Scheiner that their appearance is confined to a zone extending to 30° or 35° in latitude on either side of his equator. All subsequent observation has confirmed this. Only one fully-authenticated observation (by M. Peters, in 1846) is adduced of a spot in so high a North latitude as 50°, and a double one has been observed by Mr. Carrington in 44° S. The equator itself is, however, rarely visited by them, and this paucity usually extends over an equatorial zone, from 8° N. to 8° S. latitude. From these limits to 20° latitude on either side extends the region of their *most* frequent occurrence. Moreover it is no uncommon thing in very spotty states of the sun to observe some one parallel of latitude dotted out as it were on the disc by a more or less continuous line of spots extending across or nearly across the whole disc, and that occasionally in both hemispheres. (See Fig. 7.)

No one *meridian* of the sun, however, is found to be especially abundant in them, nor has observation yet pointed out any particular *locality* on that globe, at or near which a spot more frequently breaks out than at any other on the same parallel, a circumstance conclusive against their owing their origin to volcanic eruptions or any simply local causes.

The sun is not equally spotted at all times. Many months and sometimes whole years have elapsed without the *notice* of a spot. In others, for months, nay years together, they have been remarkable for number and magnitude. It seems to have been a very general belief up to the epoch of Professor Schwabe's observations already mentioned, that this variety was purely casual, and altogether irregular. But the evidence obtained by M. Schwabe, observing from 1826 to 1860, on an average 300 days per annum, during each of which the number of groups and single spots was registered, clearly established a periodicity. Thus, in 1833, 1843, 1856, very few groups were seen, and on nearly half the days of observation the sun was spotless; while in 1828, 1837, 1848, 1859, and 1860, the number of groups was extraordinary, and *not one* spotless day occurred; while the intermediate years exhibited a regular alternate increase and decrease. A period from ten to twelve years in duration was thus indicated. It became therefore exceedingly interesting to ascertain, by the collection and comparison of all the observations recorded of the sun's state since the first discovery of the spots, whether this alteration of periods of excitement and quiescence would be corroborated or not. This task (one of no slight labour) has been accomplished with extraordinary devotion and perseverance by Dr. Rudolf Wolf, Professor of Astronomy at Zurich, who in a series of Essays communicated to and published by the Zurich Society of Natural Philosophy, has collected from every available source the whole literature of the subject, and subjected the totality of the recorded observations to a most careful and searching scrutiny. In so doing he has been enabled to assign, on what appears to us sufficient evidence in general, and in most cases decisive, the following epochs of *minima* of solar activity (as evinced by the production of spots), with the intervals elapsed between each, *viz.* :—

Minima, A.D.	Intervals.	Minima, A.D.	Intervals.
	Years.		Years.
1610·8	8·2?	1733·5	11·5
1619·0	15·0?	1745·0	10·7
1634·0	11·0	1755·7	10·8
1645·0	10·0	1766·5	9·3
1655·0	11·0	1775·8	9·0
1666·0	12·5	1784·8	13·7
1679·5	10·0	1798·5	12·0
1689·5	8·5	1810·5	12·7
1698·0	14·0	1823·2	10·6
1712·0	11·0	1833·8	10·2
1723·0	10·5	1844·0	12·2
1733·5		1856·2	

The mean interval is $11^{y}{\cdot}2$, or, considering that the two first epochs are necessarily somewhat uncertain, very nearly $11^{y}\,\frac{1}{9}$th, or nine complete periods in a century; and the mean epoch 1799·24, which is so nearly 1800·0, that as a convenient date for memory the commencement of the terminal year of each century may be taken as a starting point. The comparison of epochs of maximum activity leads to a similar conclusion as to the length of the average period; but these epochs are less definitely marked, and subject to greater deviations from their average places than the minima which, themselves, as is evident from the above synopsis, are subject to pretty considerable irregularities. Generally speaking there appears a tendency in the maxima to anticipate the middle time between the consecutive minima, the interval 11·11 being divided into two unequal sub-intervals of $4^{y}{\cdot}77$, and $6^{y}{\cdot}34$.

Professor Wolf estimates the solar activity on any day by adding together the number of individual *spots* counted on the disc and ten times the number of *groups*. This is to a certain extent arbitrary. But some rule must be adopted for calculation, and it would not be easy to propose one less open to objection. Taking the total so obtained for each day for the measure of that day's activity, and thence calculating the mean yearly activity, and the mean during each period, he has arrived at some very striking and remarkable conclusions, which may be thus stated. 1st. If a series of equal distances be marked off in a line to represent years, and on the middle of each an ordinate erected representing the mean annual activity, their extremities being joined by a curve; this will, of course, exhibit a series of waves averaging 11·11 years in breadth. Now it is found that the summits of these waves (and also their depressions) are of very unequal heights, and that (regarding their summits only) the curve connecting these exhibits again a series of larger waves, occupying, from summit to summit, a breadth of about 56 years, or (?) five times the length of the smaller period, the maximum value of *its* ordinate being nearly double of the minimum. In other words, besides the shorter period of 11·11 years in which the solar activity fluctuates from *nil*, or nearly, so to a maximum and back again, it is subject to another and larger period of 56 years (55·55 ?), during which the extent of the former fluctuation is nearly doubled. The maximum of this greater fluctuation may provisionally be placed about the years 1780 and 1836. 2nd. Another conclusion hardly less interesting is, that in adjacent or nearly adjacent 11-year periods of unequal length, a greater degree of activity during the shorter *tends* to compensate in the total number of spots produced, for a less energy in the longer.

These results are in a high degree enigmatical, and up to the present time no clear account of them has been given. Were the spots sufficiently large and numerous to produce any considerable defalcation of light they would place the sun at once in the class of variable stars, which present distinct and marked analogies in respect of their laws of periodicity and sub-periodicity, such as at all events point to a common explanation of the two phenomena. Meanwhile it must be noted that in the planetary revolutions we find no such periods as $11\frac{1}{9}$ and $55\frac{1}{2}$ years, and although both Professors Wolf and Schmidt have bestowed some pains on the inquiry whether the application of equations or terms depending on the heliocentric longitudes of the planets may not eliminate some portion of the observed irregularities in the recurrence of the minima of the 11-year period, it does not yet appear that any dependable result of this kind has been arrived at. Indeed, the data have not sufficient precision, nor does the series of observations embrace a sufficient time to lead us to expect it.

As regards the number of spots in each year and in different months of the same year, however, Dr. Wolf ('Mittheilungen,' No. X.) seems to have satisfied himself from the examination of Schwabe's observations from 1826 to 1848 that sub-periods depending on the revolutions of the *Earth* and of *Venus* do really exist. Thus, he finds a perceptibly greater degree of apparent activity to prevail *annually* on the average of months of September . . . . . January, than in the other months of each year—and again by projecting all the results in a continuous curve he finds in it a series of small undulations succeeding each other at an average interval of 7·65 months, or 0·637 year. Now the periodic time of Venus (225 days) reduced to a fraction of the year is 0·616, a coincidence certainly near enough to warrant some considerable suspicion of a physical connection.

Yet more enigmatical is the connection which has been considered to subsist between the mean annual abundance of solar spots and the extent of mean annual fluctuation observable in the magnetic elements which determine the position of the needle. Dr. Lamont, of Munich, it would appear, was the first who noticed a periodical increase and decrease in the annual amount of variation of the magnetic declination—the period assigned by him being about ten years. In his 'Resultate der Mag. Obs. zu München,' published in 1846, he states the amount of the mean daily variation in declination for the eleven years from 1834 to 1845 inclusive, which exhibit an increase from 8′·25 in 1834 to 12′·90 in 1836, whence a gradual and steady decline to 7′·41 in 1844. And from this (which as we now perceive falls in perfectly with the increase and decrease of the spots in that interval, but without reference to them) he drew the conclusion above mentioned. A similar result was announced in 1852 by General Sabine, and extended to all the magnetic elements—connecting the periodicity with that of the spots, but assuming a period of ten years in accordance with M. Schwabe's first conclusion—and to this period of magnetic change General Sabine we believe is still disposed to adhere. Professor Wolf, however, who has instituted the same system of inquiry into all available observations of magnetic declination, finds this element at least (*so far as dependable observations exist*) to vary in so perfect accordance with his law of solar activity that a table of its mean annual amounts as estimated in the manner above stated is convertible by a mere change of scale and the use of a multiplier constant for each magnetic observatory, into a table of mean decimal variations for the same years in each. It will be recollected, however, that the earlier data here are sparingly scattered, and it would be premature to assert the absolute generality of this conclusion in the face of that to which the Astronomer Royal has been led by his recent elaborate discussion of the Greenwich magnetic observations from 1841 to 1857, *viz.*: that from the rapid decrease of dimension in the projected curves for the several years from 1848 to 1857, their forms remaining the same he is led to believe that in this interval "*some great cosmical change has come upon the earth affecting terrestrial magnetism.*" We should not pass quite unnoticed, however, that, granting the correctness of the epoch of maximum (1836) of Dr. Wolf's longer period of 56 years, this precise interval of time would fall upon the most rapid downward sweep of his average curve of maxima during its progress from the maximum of 1836 to that of 1892.

A connection between the periodicity of the spots and the recurrence of great displays of aurora borealis has also been surmised, and was, indeed, suggested as a possibility by Mairan more than a century ago. The recent researches of Professor Fritz, grounded on a diligent assemblage and collection of recorded auroras instituted by Dr. Wolf, the late Professor Olmsted, and others, have placed this connection in a very distinct light, and shown not only that the 11-year period of the spots has its parallel in the annual frequency of auroras, both in respect of number and the epochs of minimum, but also that the long period of 56 years is represented in that phenomenon, and, in fact, agrees better in indicating epochs of extraordinary abundance and paucity than a longer period of 65 years proposed by Olmsted, without reference to the spots. To dilate on the steps of this inquiry would lead us beyond our limits, and we hasten to the consideration of another class of phenomena, to which observations of Mr. Carrington, from 1853 to 1861, recently published with the liberal aid of a grant from the Royal Society, have given a very prominent degree of interest, as affording at length a glimpse—if not of the physical cause in which the spots originate, at least of the working of a mechanism through which that cause may possibly produce its effect.

We have already noticed, that while the results obtained by different observers and computists as to the position of the sun's axis of rotation derived from the paths of the spots across his disc agree on the whole satisfactorily, no such good accordance is found between the times of rotation so deduced. Galileo concluded from his observations (of course rudely) a synodic period of 28 days; Scheiner, in 1630, of 26 or 27, corresponding to a *sidereal* period of 25½, or thereabouts; Cassini, 25·59; Lalande, 25·42; Laugier, as a mean result, 25·34; Kysæus, 25·09; and Boehm, 25·32; the discordance between which is too great to be considered satisfactory. Observers, moreover, had noticed that, not only different spots gave different results, but that the same spot observed in several successive revolutions gave results greatly at variance with each other. Thus the observations of M. Laugier afforded periods varying from 24·88 to 26·23 days; and Professor Fearnley of Christiania, from observations of a very remarkable spot in 1857, which presented itself three times on the disc, deduced a series of periods from its passages across and reappearances on the disc, of 25·46, 25·67, 25·83, 25·87, and 26·23 days, respectively and successively. Such differences are far too great to have arisen from error of observation, and can only be attributed to proper motion of the spots themselves relative to the body of the sun, arising from their floating in the solar atmosphere, of which their relative change of heliographical situation suffices of itself to indicate the movement. This conclusion was drawn by M. Peters, from an elaborate series of observations made in 1845-6, in which he first clearly pointed out that the period of rotation deduced from such observations is that of the sun's atmosphere, not of its globe, and is affected, for any particular spot, by whatever atmospheric drift, permanent or temporary, may subsist in the region occupied by it. Thus a way was opened by assiduous observations of the spots to a knowledge of the existence and laws (if any) of the solar atmospheric currents. About the same time was put forth by the author of this notice, a surmise, from the law of distribution of the spots in two tropical belts, with an intermediate spotless equatorial zone, that their origin might perhaps be sought in regular solar winds, analogous in their essential features to our trade-winds, and owing their origin to a different rate of *emission of heat* in the equatorial and polar regions, and a consequent difference of temperature in the two regions.* On the occasion of the spot-minimum of 1855-6, Mr. Carrington, who from 1858 downwards had been assiduously and systematically observing them, was led to make a very important remark as to the distribution of the spots *in latitude.* He found that, as the epoch of the minimum drew on, their average heliographical latitude decreased; the higher latitudes beyond 20° N. and S. becoming deserted, while the equatorial zone became comparatively more and more frequented by them; and this went on steadily till the epoch of the minimum was attained. After this a sudden and most decided change took place. The equator was deserted, and on the reappearance of the spots their average latitudes, N. and S., were found to exceed 20°, the intermediate zone being now as remarkable for their relative paucity as it was before for their relative abundance. On

* 'Results of Cape Observations, 1847.'

searching former records, Dr. Wolf ascertained from the observations of Professor Boehm in 1833-4-5-6, including the minimum of 1833-4, that the same phenomenon had then also occurred, the average latitudes of the spots in 1833 having been 9° 9′, while in 1834, the year immediately subsequent to the minimum, it had risen by a similar sudden spring to 25° 0′, after which (as was also the case in Mr. Carrington's observations) it gradually declined to the normal state. Whether this be a general rule, remains to be seen. If so, it cannot but stand in immediate and most important connection with the periodicity itself, as well as with the physical process in which the spots originate. Meanwhile, however, an opportunity was thus afforded of determining the sun's period of rotation by a great many equatorial spots, as well as by those in high latitudes. The results have been computed and synoptically tabulated with consummate skill and diligence by Mr. Carrington, in the extensive and laborious work already cited, and lead to the following general and highly-remarkable conclusion—*viz.* that the period of rotation as deduced from spots in different latitudes increases with the latitude so far as 50° (beyond which no observations are attainable), or, in other words, that the equatorial regions of the photosphere revolve considerably faster than the polar. According to the law of dependence between the rotatory velocity and the corresponding latitude assigned by Mr. Carrington,* the difference amounts to no less than 5·89 days, the sidereal revolution at the equator being 30·86 days, and at the pole (supposing the same law carried on up to the pole) 24·97 days. At 50° hel. lat., the revolution would be completed in 28·36 days.

Let us now consider what is implied in the law so disclosed. This will depend much on the supposition we may make respecting the rotation of the interior globe, of which we are left in complete ignorance. As extreme hypotheses we may suppose its rotation to be performed in the least of the above-named times, or in the greatest; or, as a *mezzo termine*, in the intermediate period last mentioned.

I. On the first hypothesis, the equator and the photosphere above it will be relatively at rest, and we shall have in analogy to the state of things prevalent here on earth, a region of equatorial calm, not much disturbed for some small number of degrees, &c., to the North or South. As the latitude increases, the photosphere, revolving in continually longer and longer time, will lag more and more behind the surface of the globe for the time beneath, the result being of course what we should call an "East † wind," or relative current from East to West, increasing in intensity with the increase of latitude, and attaining, according to Mr. Carrington's formula, a maximum of intensity (estimated by the *linear* amount of momentary retardation) at

* Mr. Carrington's formula for the amount of diurnal rotatory movement in longitude for a spot in latitude l is 865′—165′ (sin. l $\frac{7}{4}$, which is not *very* different from 700′+165′ (log. l)^2, which, however, he repudiates as representing the observations less closely.

† Great and habitual confusion arises from the use of the words East, West, Easterly, Westerly, as indicating direction. By an East wind, we would be understood to mean a wind blowing *from* the East; by an Easterly current or drift, whether of air or water, one which sets *from* West *towards* the East.

52° 49′ hel. lat.: that is to say, almost exactly at the latitude where the spots cease to afford us any further information. Its velocity estimated as a surface current at this latitude would be 357 miles per hour.

There is a considerable analogy in such a system of movements to our N.E. and S.E. trade-winds. These also are *nil* in intensity on the equator, and increase in strength with the latitude, up to a certain maximum. This, it is true, occurs in a considerably lower latitude than 53°, but in our ignorance of the law of distribution of temperature over the sun's surface, this can hardly be considered a fatal objection, especially when coupled with the very moderate velocity (for such a globe as the sun) assigned as their maximum. To render it applicable, the photosphere (within the maculiferous region) must be assumed to float, and be entirely contained in the *indraft* current (that which sets towards the sun's equator), and this must also be (within that region) the *upper* current, to provide for the carrying back into the circulation and redistribution of its matter (perhaps in a less luminous state) over the general surface, by the lower: constituting possibly the lower envelope which forms the penumbra of a spot; the spot itself, both umbra and penumbra, being a region in which, owing to some cause of disturbance, the movement of the lower current is arrested, and thrown into eddies and ripples. In this view of things, the temperature of the equatorial atmosphere must be supposed generally lower than that of the polar, which is not incompatible with, but on the contrary may be caused by, *a more copious emission of heat* from the former region, which, as Professor Secchi assures us, is really the case.

II. On the second of our two extreme hypotheses, that which makes the globe of the sun revolve in $30^{d}\cdot86$, the conclusion is very obvious. As the solar atmosphere must then in its entirety revolve quicker than the enclosed globe. there must prevail at every point of the surface of the latter a steady and uniform *West wind*, increasing regularly in intensity from *nil* at the poles, up to 880 miles per hour at the equator. As this current must continually tend to accelerate the rotation of the globe by friction, which by the law of reaction must tend to induce a state of relative quiescence, while yet the exterior current is maintained unabated—this can only be by a force *ab extra*, and we have nothing to fall back upon for such a force but the friction of external matter circulating round the sun according to the laws of planetary motion, and that of the zodiacal light (the plane of whose greatest extension according to the best account we have of it, coincides with the sun's equator) is ready at hand. In that case between a rotation in 25 days, that of the photosphere, and 3 hours that of planetary matter revolving freely at 1-10th of the sun's radius above its surface, *i. e.* between a velocity of 4,609 miles per hour in the former, and 1,012,000 in the latter case, every intermediate gradation of velocity must subsist, while between the photosphere and the globe a difference of velocity of only 880 miles per hour exists.

However enormous this velocity of the external matter, and whatever the density we may attribute to it, we have to accept this last-mentioned acceleration in the (no doubt exceedingly rare) matter of the solar atmosphere at the level of the photosphere, *as the measure of the final result of its impact and friction.* And on the theory of the frictional generation of the sun's heat, it is the amount of *vis viva* so delivered into the sun to which we have to look for the maintenance of its supply of heat. It would be superfluous to adduce arguments, to show the utter inadequacy of the cause to produce the effect. *If this be all*, the origin of the solar heat is as much a mystery as ever.

III. The intermediate hypothesis may be very summarily dismissed. It has not the merits of either extreme, and is in contradiction to both. It supposes a permanent west wind on the equator, and is therefore inconsistent with any Etesian theory (of a system of trades and anti-trades)—and a permanent set of the whole atmosphere, beyond a given latitude, *to the westward*, equally contradictory to the theory of an external drift, the result of planetary circulation.

Between the two extreme hypotheses there would seem to exist a crucial means of discrimination. The first undoubtedly seems to presume an average tendency of the spots towards the sun's equator, while the latter involves no conclusion either to that or the contrary effect. On this point however, observation is not very positive. Professor Peters is of opinion that there *is* such a tendency, while Mr. Carrington seems to think the contrary. His synoptic table (Observation of Solar Spots, p. 220) exhibits an average, though very small preponderance, in favour of a general movement *towards the poles*, on either side of the equator—but the individual differences, to whatever cause attributable are so very much greater, as to destroy all confidence in such a conclusion. From the result of Professor Fearnley's observations on the spot of 1857, whose periods of return went on successively increasing on each reappearance of the spot, it may fairly be concluded that the spot was *receding* from the equator. Unfortunately I have not been able to ascertain whether such was really the case.

Mr. Carrington puts forth a surmise (p. 248) whether some part of the irregularity in the maculiferous activity of the sun may not arise from the action of Jupiter on the zodiacal light. To appretiate the probability of this we have only to consider—1st. That the zodiacal light can hardly extend beyond the orbit of the earth—assuredly not its denser portions. 2nd. That its medial plane is that of the sun's equator, which is inclined 5° or 6° to the orbit of Jupiter, so that it is only when near their common node that any action, even on the infinitely attenuated portion of it which may reach so far, can take place. And 3rd. That whatever be the form of the zodiacal light *in section*, we have no reason to believe it other than circular *in plan*.

Let us suppose, however (and such a supposition has not been deemed inadmissible in attempting to account for the periodical return of meteors), the existence of an elliptic ring of vaporous, nebulous, or small planetary matter, with such a major semiaxis (4·979) as corresponds to a periodic time of each of its particles $=11{\cdot}11$ years; of such eccentricity as to bring its perihelion within the limits of the solar envelopes; and revolving either in the plane of the ecliptic or in some other plane at a more considerable inclination to the sun's equator. Let it be further assumed (still in analogy with assumptions not regarded as unreasonable in the meteoriferous ring), that the distribution of the circulating matter in it is not uniform—that it has a maximum and minimum of density at nearly, but not quite, opposite points, and no great regularity of gradation between them. It is very conceivable that the matter of such a ring introducing itself with planetary velocity into the upper and rarer regions of the sun's atmosphere, *at an incidence oblique to its regular and uniform equatorial drift*, might create such disturbances as, either acting directly on the photosphere, or intermediately through a series of vortices or irregular movements propagated through the general atmosphere, should break its continuity and give rise to spots, conforming in respect of their abundance and magnitude to the required law of periodic recurrence. If the change of density from the maximum to the minimum were gradual, but from the minimum to the maximum more abrupt, so as to allow the disturbances to subside gradually, and recommence abruptly—the fresh and violent impulse would be delivered first of all on a region remote from the equator (by reason of the obliquity of the ring), and would give rise to a recommencement of the spots in comparatively high latitudes.

If the section of such a ring as we have supposed at its aphelion were *nil*, the period of 11·11 years would be strictly carried out; the maxima and minima would succeed each other with perfect regularity, and the paucity and abundance of the spots in the several phases of the same period would follow a fixed ratio. But if not, the several parts of the ring would not revolve in precisely equal times—the period of 11·11 years would be that of some dominant medial line, or common axis of all the sections in which a considerable majority of its matter was contained—and the want of perfect coincidence of the other revolutions would more or less confuse, without obliterating the law of periodicity, which, supposing the difference to be comprised within narrow limits, might still stand out very prominently. Now it might happen that there were two such medial lines, or more copiously stocked ellipses, each having a maximum and minimum of density, and that their difference of periodic times should be such as to bring round a conjunction of their maxima in 56 or any other considerable number of years: and thus would arise a phenomenon the exact parallel of Dr. Wolf's long period and his series of greater and lesser maxima.

It will, of course, be objected that the resistance of the solar atmosphere would retard and ultimately destroy such a ring. But we must bear in mind the extreme tenuity of this atmosphere in its upper regions, and that our ring need not consist of mere vaporous matter. It might be a collection of exceedingly small planetules, which, however thinly dispersed over an immense space *in aphelio* and in the remoter parts of their orbits, would become crowded together *in perihelio*, acting as it were by a joint *rush* to produce the disturbance, but each individually suffering a resistance infinitesimal compared to its inertia. The comet of 1843 passed within the region we are contemplating, and its motion was not destroyed.

The orbits of our planetules would in fact be, *par excellence*, cometary; they would surround the sun very closely for nearly half its circumference; and if their common perihelion should occur in or near the longitude which the earth has in December, a preponderance of spots in the autumn and winter months would be far from improbable.

Our ring might lie in the plane of the ecliptic or near it, and so might intersect the orbit of the Earth, or Venus, or Jupiter. Of the influence of such intersection we may conjecture much, but can discern nothing distinctly; and our readers may be disposed to think that we have advanced far enough already into the regions of conjecture.

STEAM NAVIGATION, ITS RISE, PROGRESS, AND PROSPECTS.

By Martin Samuelson, Member of the Institute of Civil Engineers.

It seldom occurs to the active minds engaged in the consideration of man's age, and his relations to the lower animals, that, in order to arrive at accurate conclusions upon these subjects, it is necessary, not only to study the traces he has left behind him in the earth's strata, and the history of his recent physical development, but also to direct the attention to the method in which he has executed plans that seem to have been prompted by some superhuman—nay, why need we hesitate to say—Divine agency.

How does it happen that throughout the thousands of years in the historic record, as well as in the ages before the supposed date of his creation, during which we are now taught to believe that man existed in dark ignorance, not the remotest idea appears to have occurred to him of the practicability of rendering the physical forces subservient to his will; and that up to the commencement of the present century, his utmost attainments were unable to rescue him from the power of the elements? For it is only an affair of yesterday that he was bound to go or stay, to lie becalmed or be driven he knew not whither across the boundless main, as it pleased the volition of the tempest.

And again, dismissing for the present the consideration of the marvellous strides which were made in the new locomotive enterprise after it was once fairly started, is it not a matter for reflection, as we look abroad over the nations of the earth, to find perhaps side by side with the Leviathan (for it is more than probable that she may one day be ploughing her way across the Pacific Ocean) the hollowed-out trunk of a tree, the primitive boat, filled with naked savages and propelled by paddles which, with the boat itself, may have been shaped by means of the serrated bone of some predaceous fish?

Who will venture, with such a contrast before his eyes to-day, to assert that man—that is, *reasoning* man—is not a creature of yesterday?

It appears to us to be the Creator's intention, just as He has preserved for us the fossil remains of extinct species of animals, in order to afford us a retrospective glance over the early history of the globe and its animated freight, to have retained also, fresh and living before our eyes, the illustrations of aboriginal barbarism in the persons of men accompanied by their primitive appliances, so that we may not excuse ourselves, through ignorance of the past, from seeking to afford a worthy example, and to mould the minds of future generations.

These are indeed interesting subjects for the consideration of ethnologists and anthropologists; but unfortunately (or perhaps we should say fortunately for our readers) we are unable to proceed with such inquiries, for we are reminded that we have undertaken, in the space of a few brief pages, to furnish a retrospect of the past history of Steam Navigation, and to indicate, in as many lines, what we believe to be its future prospects. Nor have we, in the performance of this task, to overcome the last-named difficulty alone; that is, of condensing into a few pages the history of what we shall term a scientific art, upon which many volumes, some of them of no mean proportions, have been written. There is still another fence between our readers and ourselves, and that is one in which we shall seek only to break a gap for the purpose of opening a communication with those who are likely to be interested in our brief story. Should the heads of this narrative have the effect, as we trust they may, of whetting their appetites, and of causing them to long for deeper draughts from the sources whence we have drawn, then indeed they must widen the passage for themselves, and effect an entrance into *our* field; for it would be impossible for us to drag all our technicalities through the narrow aperture which enables the practical man of science to hold converse with the popular reader, or the tyro in knowledge.

Steam Navigation has, during the brief period of its existence (for its history extends but over half a century), attained a degree of perfection which may not be excelled for generations to come. It has linked, more closely the tropics and the poles, the old world and the new; and, with the exception, *perhaps*, of the Electric Telegraph, there is no modern invention that has effected more in the cause of civilization than the engine for marine locomotion. Even in its relation to Electric Telegraphy, everyone must admit that it has been the immediate precursor, if not the instigator, of that power; for what was left to man after he had succeeded in holding communication with his fellows thousands of miles away, in the course of a few days, converting him who was a stranger in distant climes into an immediate neighbour—what remained for him, we say, but to contrive the means of bringing this one still nearer, for the purpose of conversing with him as though they abode under the same roof? Was it not over the well-trodden path of the Millers, the Fultons, the Watts, and the Stephensons, that Wheatstone conceived the idea of winging his flight?

Indeed, with the discovery of steam navigation there commenced quite a new era in the history of our race. Many physical and mechanical difficulties had to be overcome before sufficient progress was made in the art to make it the means of extending the commerce of the world, of nourishing the poor with better food, or of providing fresh comforts and luxuries for the rich; but greatly as we may plume ourselves as Englishmen upon the share we have had in its rapid development, still it behoves us, in the spirit of impartial chroniclers, to award the merit of the first discovery not to one of our own nation, but to an intelligent and enterprising foreigner—a Spaniard.

Perhaps the earliest account we have of a vessel being propelled by steam power is contained in some manuscripts in the archives of Salamanca; these appear to prove that in the year 1543 a naval captain, named Don Blasco de Garray, invented a machine moved by steam, and capable of propelling ships independently of oars or sails. The apparatus referred to was fitted to a vessel of about 200 tons, called 'La Santissima Trinidada,' and an experiment was conducted in Barcelona Roads on the 17th June, 1543, in the presence of the Emperor Charles V., his son, Philip II., and many illustrious persons, which resulted in the ship's attaining a speed of one league per hour; but the apparatus appears to have been condemned, and no further attention was given to it, on account of the apprehension of explosion from the boiler, and the great complexity and expense of the machine; although the Emperor is stated to have reimbursed De Garray for all the expenses he had incurred in making his experiment.

In 1736, Jonathan Hull took out a patent for applying the steam-engine as a motive power to propel ships; and quoting from the description of the invention, we have the following:—"It has been demonstrated that when the air is driven out of a vessel of 30 inches diameter, the atmosphere will press on it to the weight of 4 tons 16 cwt.; and when proper instruments are applied to it, it must drive a vessel with great force." He also described the machinery for working a pair of paddle-wheels, and a drawing was given, representing a tug towing a two-decker against the wind, this tug having a chimney from which smoke issued, and in the after part of the boat was an engine working two paddle-wheels attached to spars abaft each quarter. But the steam engine was at this time in a very imperfect state, so that no practical success was attained, although a vast number of experiments were made by many ingenious men.

It was not until the towering genius of Watt had made the steam-engine the complete and elegant machine that it now is, that steam navigation began to exhibit any signs of success; and we therefore pass over the various experiments (many of them unsuccessful) which were made, until we come to those of William Patrick Miller, who in 1787 took out a patent for paddle-wheels (very similar to those at present used) for propelling vessels; and a Mr. Symington having about this time patented a new application of the steam-engine, was introduced to Mr. Miller; and they between them contrived to make a small steamer, which moved at the rate of five miles per hour; but this was little more than a toy, as the cylinder was only 4 inches diameter. It may be interesting to the reader to know that the engine last referred to may be seen in the South Kensington Museum.

In 1788, John Fitch obtained a patent for the application of steam to navigation in the states of Pennsylvania, New York, New Jersey, and Delaware ; he induced several moneyed men to assist him, and after a considerable outlay, constructed a steam-boat, which, however, only attained a speed of 3 miles an hour. The shareholders were, notwithstanding, induced to make another trial; and a second vessel was completed, which went 8 miles an hour.

Another American, James Ramsey, had also taken out a patent, and in 1788 he came over to England, where he induced a wealthy American merchant to join him in building a steam-boat; but Ramsey died before its completion. The vessel was finished and afloat in 1793, when she made several trips on the Thames, effecting about 4 knots per hour.

In the year 1801, Lord Dundas, a large proprietor in the Forth and Clyde Canal, employed Mr. Symington to conduct a series of experiments on steam-boats, in order that they might be substituted for the horses which were used for drawing the canal boats. These experiments resulted in the construction of the *first practical steam-boat*, named the 'Charlotte Dundas.' The particulars of the trial of this boat are described as follows :—

"Having previously made various experiments, in March, 1802, at Lock No. 20, Lord Dundas, the great patron and steam-boat promoter, along with Archibald Spur, Esq., of Elderslie, and several gentlemen of their acquaintance, being on board the steam-boat, took in tow two loaded vessels, the 'Active' and 'Euphemia' of Grangeworth, Gow and Ephine masters, each upwards of 70 tons burden, and with great ease carried them through the long reach of the Forth and Clyde Canal to Port Dundas, a distance of 19½ miles, in six hours, although during the whole time it blew a very strong breeze right ahead, so much so that no other vessel could move to windward in the canal that day."

This placed beyond a doubt the utility of the steamer in canals and rivers, and ultimately on the seas. In spite, however, of the great success of this experiment, objections were raised by the proprietors of the navigation to the use of steam-boats, fearful lest the banks of the canal would suffer from the wash of the undulation produced by the paddle-wheels. The 'Charlotte Dundas' was therefore laid aside, and, with very few exceptions, no further experiments have been made with steam navigation in canals; where such has been the case, the screw has been resorted to.

In 1806, Robert Fulton, an American engineer, commenced a steam-boat, which was completed in 1807, and destined to run between New York and Albany, a distance of 120 miles, which she accomplished in about 30 hours. The terror and surprise of the people at Albany was very great when they saw this strange ship approaching them, and is thus described by an American journalist :—

"She had the most terrific appearance from other vessels that were navigating the river. The steamer, as many do now in America, used dry pine wood for fuel, which sent forth a column of ignited vapour many feet above the flue; and whenever the fire was stirred, a galaxy of sparks flew off, and in the night had a very beautiful appearance. Notwithstanding the wind and tide were averse to its approach, they saw with astonishment that it was rapidly coming towards them; and when it came so near that the noise of the machinery and paddles was heard, the crews in some instances shrunk beneath their decks from the terrific sight, and left their vessels to go ashore; while others prostrated themselves and besought Providence to protect them from the approach of the horrible monster which was marching on the tide, and lighting its path by the fire which it vomited."

She was called the 'Clermont,' and was the first steamer which, as well as being a practical success, remunerated her owners.

About this time, a countryman of Fulton's, John Cox Stevens, had completed a steamer; but as Fulton had obtained the exclusive right of navigating the waters of the state of New York, Stevens boldly determined to convey his ship to the Delaware by sea: he was thus the first who took a steam-boat to sea. Fulton had much prejudice to overcome in introducing steam navigation, but the Americans soon became aware of the immense commercial advantage that must result from its adoption, and accordingly steamers multiplied with great rapidity, so that in the year 1821 there were not less than 300 steamers at work in America.

Returning again to England, it was not until the year 1812 that steam navigation was brought into practical use in this country, when Mr. Henry Bell started on the Clyde a small steam-boat, called the 'Comet.' She was only 40 feet long, 10 feet 6 inches beam, and of $3\frac{1}{2}$ horse-power. There was nothing novel in this small boat, and, in fact, Symington's 'Charlotte Dundas,' which has already been referred to, was a far more perfect steamer than either Fulton's 'Clermont' or Bell's 'Comet;' but great merit is due to Bell that he succeeded in establishing steam navigation in this country, just as Fulton had done in America. To Symington, however, is due the honour of having constructed the first practical steam-boat.

From this time the number of steam-boats began to augment with astonishing rapidity, not on the Clyde alone, but on many of the principal rivers of England. The steam navigation of rivers having now become an established fact, enterprise soon determined that steamers should be sent to sea. Accordingly, in 1815, the 'Rob Roy,' a steamer of 90 tons and 30 horse-power commenced running between Glasgow and Belfast, and was therefore the first regular sea-going steamer in England.

In 1816, several wealthy men formed a company for the purpose of establishing a line of steamers between Dublin and Holyhead; they had two built, the 'Britannia' and 'Hibernia,' both of 107 tons and 20 horse-power. In this early stage of steam navigation they accomplished the run with tolerable regularity, but the defects in the form of the ships and the imperfection of the machinery caused them eventually to be placed on one side. The problem of making successful sea-going steamers being now thoroughly solved, they began rapidly to increase their numbers, and steam navigation quickly extended to other countries, France, Russia, and Holland all pressing forward to participate in the grand invention. It would be needless to enumerate the various steamers which now made their appearance in every part of this country.

The first regular steamer which plied on the Thames was the 'Margery,' of 70 tons and 14 horse-power. She made the trip from London to Gravesend in one day, returning the next; but another steamer, called the 'Thames,' soon eclipsed her performance, making the trip there and back in the same day.

In 1822, a company was formed, with the bold idea of establishing a steam communication with India by what is so well known as the Overland Route. It became necessary that steamers should be placed in the Red Sea to meet those coming from England, and accordingly a vessel called the 'Enterprise' was built and launched by Messrs. Gordon of Deptford, in February, 1825; she was rigged as a three-masted lugger, and was fitted with engines of 120 horse-power, by Messrs. Maudslay. The boiler was of copper, and in one piece, weighing 32 tons; her consumption of fuel was about 12 tons per 24 hours. She sailed from Falmouth deeply laden with coal for the voyage, on the 16th August, 1825, and arrived in Diamond Harbour, Bengal, 7th December, the distance being 13,700 miles; which was therefore accomplished in 113 days, whereof 63 were under steam and 40 under sail, the remaining ten days having been occupied in cleaning her boiler at St. Thomas and in coaling at the Cape. The result of this experiment was very disappointing, both to the public and the shareholders, as they had anticipated that less than 80 days would have sufficed for the voyage. Government, however, bought the ship for 40,000*l.*, so that the enterprising speculator lost but little; she was used in the Burmese war with great success. Although, however, the 'Enterprise' had not realized the expectation of the projectors, we cannot but regard her as a success, for she was in a great measure the pioneer in long steam sea-voyages.

In 1827, Government established a line of steamers between Falmouth and the Mediterranean; these vessels averaged throughout the year 7½ knots per hour. At Bombay, in 1830, a steamer was built of 400 tons burthen and 160 horse-power, named the 'Hugh Lindsay,' with the object of establishing steam communication between Bombay and Suez; and on the 20th March she started from Bombay, and reached Aden (where a coaling station had been provided) on the 7th April, and thence to Suez, where she arrived on the 29th May. This voyage fulfilled its object in showing the practicability of a rapid steam communication with Europe, and eventually led to the establishment of the Peninsular and Oriental Company.

In 1836, a company was incorporated at Bristol with the magnificent project of Transatlantic steam navigation. Hitherto, no steamers of any great magnitude had been constructed, and those which had made long voyages had depended on their sails as much as on their steam power; but this company, which was called the Great Western Steam Navigation Company, felt convinced that to convey passengers and mails with regularity, they must depend on their steam power only. To accomplish this, however, the ship would be compelled to carry a very large quantity of coal, and must be provided with great engine power; she would therefore have to be constructed of such dimensions as would enable her to comply with these requirements; hence they determined to build a ship of wood, called the 'Great Western.'

She was built at Bristol in the year 1837, by Mr. William Patterson; her principal dimensions being 212 feet by 35 feet beam and 34 feet deep. These dimensions were at that time considered gigantic, and the idea of being able to make a steamer of these proportions (that is to say, of so great a length in comparison with her breadth) to cross the Atlantic with safety was scouted by many scientific men as utterly impracticable; one of the great objections raised being that such a ship must inevitably break her back when poised between two waves, the middle being unsupported. Dr. Lardner was the foremost amongst the scientific men of the day who proved most satisfactorily to "himself" that the 'Great Western' must be an utter failure, both from a scientific point of view and also as a mercantile speculation; and yet Lardner has compiled many really useful works, and has manifested considerable intelligence on most subjects with which he has dealt. It certainly shows us how easily scientific theorists, arguing from assumed data and not from experiment, are led to make the most positive assertions, which prove to be wide of the actual results; at the same time we must not forget that sound practice can only be acquired in conjunction with, or assisted by, sound theory; the latter should, however, always be deduced from careful experiment.

In spite of the forebodings of Dr. Lardner and other wise prophets, the 'Great Western' was built and successfully launched, being at that time regarded as a greater wonder than is the unfortunate 'Great Eastern' at this day.

She was fitted with side lever-engines of 420 horse-power, manufactured by Messrs. Maudslay, Sons, and Field, of London; the cylinders were 74 inches diameter, with a stroke of 7 feet; the paddle-wheels were 28 feet diameter, the paddle-boards being 10 feet long, 2 feet wide, and 20 in number. At length this wonder of steam-ships was ready for sea, and on the 8th April, 1837, she started on her first voyage across the Atlantic, with only 7 passengers on board. The run to New York was accomplished in 15 days 10 hours, which was certainly for that time a very remarkable performance; and towards the end of May she made her appearance in England with 66 passengers, having performed the voyage in 14 days; thereby falsifying the sage predictions of those worthy philosophers who had so confidentially prophesied her incapacity to cross the Atlantic Ocean. She continued to run with the greatest success, weathering the most tremendous gales, and proving herself to be what might well be called, even in these advanced days of steam navigation, a most satisfactory ship. As a specimen of sound shipbuilding, good engineering, and mercantile prosperity, she was an unexceptionable undertaking. She was economical with her coal, burning from 36 to 42 tons per day, or about 4 to 4½lbs. per indicated horse-power per hour, a consumption of fuel quite as economical as that of the average of steamers at the present time, so that we have not effected much in the economy of fuel within the last twenty-five years.

This admirable steamer was broken up only a few years since in the Thames.

By a strange coincidence, a steamer called the 'Sirius' started on the same day with the 'Great Western,'—the 8th April; she also was designed with the same object as the 'Great Western,' but she occupied 19 days in making the voyage from Cork to New York, notwithstanding that she was aided by her sails; so that to the 'Great Western' is due the glory of having first completed a successful transatlantic voyage, and she crossed the Atlantic no less than 84 times between her first voyage and the year 1844.

The complete success of the 'Great Western' led the directors of the Great Western Steam-Ship Company, under the advice of the late Mr. Brunel, to greatly extend their former efforts, and a steamer of colossal dimensions was projected as being likely to prove a proportionately greater success, both as a ship and as a mercantile speculation. The celebrated steamer 'Great Britain' was the result of this determination. But at this time the use of iron in preference to wood for shipbuilding purposes was strongly advocated by many able men, and several iron steamers had already been most successfully constructed; hence, after careful investigation into the comparative merits of iron and wood, and with the advice of Mr. Brunel, it was resolved that the new ship should be built of iron. Her principal dimensions are—length between perpendiculars, 289 feet; breadth, 51 feet; depth, 32½ feet; tonnage, 3,433 old measurement. The keel of the vessel was laid in July, 1839, and she was launched in the presence of his Royal Highness the late Prince Consort, 19th July, 1843.* At that time she was considered of gigantic proportions, and we cannot but admire the bold enterprise and masterly conception of the projectors. She naturally excited intense curiosity, and was visited by immense numbers of spectators, including shipbuilders, engineers, naval officers, and distinguished savants of every nation. At this time Mr. Smith had most satisfactorily developed the fitness of the screw as a propeller for steam-ships in the elaborate experiments of the 'Archimedes' and H.M.S. 'Rattler.' It was with the latter vessel that an interesting experiment was tried, for the purpose of comparison between the screw and paddle-wheels as propellers. The 'Rattler' was precisely the same form and power as the 'Polyphemus' paddle-steamer. The two ships were tied together, and steamed away as rapidly as they could; the result being that the 'Polyphemus' had to give in to her rival, the 'Rattler.' Mr. Brunel, in consequence, strongly advocated the application of the screw to the 'Great Britain,' and it was finally determined that she should be fitted with one. She was therefore provided with very ponderous machinery of 1,000 horse-power; the engines consist-

* A period of four years. What would become of Steam Navigation, and in fact, of the commerce of this country if shipbuilding had remained stationary in this particular? There are now firms in England who can, *in one year*, execute orders for vessels in the aggregate amounting to six times the tonnage of the 'Great Britain.'

ing of 4 cylinders, 88 inches diameter and 6 feet stroke; on the shaft of the engines a great drum, 18 feet diameter, was fixed, and the screw shaft was also provided with a drum 6 feet diameter, and the motion was communicated from the engine to the screw shaft by means of four chains, so that the screw made three revolutions to one of the engine. She had six masts, with iron rigging, as offering less resistance to a head wind than the ordinary rigging. The mid-ship section of the ship is of a peculiar form, the sides falling in very much, so that at a light draught she would not be nearly so broad at her water-line as at a deeper immersion; but before she left the works it was deemed advisable to put her machinery on board. The effect of this was that she was brought to her bearings at the greatest beam, and having to pass through a lock, it was found that the widest part of the ship came in contact with it, and it was necessary to widen the upper portion of the lock to enable the vessel to pass through into the river. At last she started on her trial trip, and her machinery and propeller gave the greatest satisfaction. She made the voyage across the Atlantic in the most successful manner until she was unfortunately stranded in Dundrum Bay, where she lay a whole winter; but by the unceasing efforts of Captain Claxton and Mr. Bremner, she was at length raised, removed from her perilous situation, and taken to Liverpool, where she was thoroughly repaired. Her machinery having been most seriously injured, it was taken out and replaced by a pair of oscillating geared engines, by Messrs. John Penn and Son, of 500 horse-power, or only half the power with which she was originally provided; but with these new engines she accomplished even a greater speed under steam than she had attained with the old machinery, which was altogether disproportionate to her size. Her rig was also altered, and she is now ship-rigged, and as handsome as any steamer entering the port of Liverpool. She has made some of the fastest voyages to Australia and back on record, and may fairly be deemed one of the most successful and splendid steamers ever built.

The 'Great Western' having led the way, there were soon plenty of followers, and magnificent steamers began to multiply, amongst which we may mention the 'British Queen' and the 'President,' the total loss of which was such a terrible disaster in the early days of transatlantic steam navigation. Then we have the splendid fleet of the West India Mail Company; the Collins' line, with its 'Arctic,' 'Pacific,' 'Baltic,' 'Atlantic,' &c.; the Cunard line, with its 'Acadia,' 'Asia,' 'Arabia,' and the magnificent 'Persia' and 'Scotia.' The 'Persia' constituted another great advance in size and speed. This magnificent steamer was built by Mr. Robert Napier, of Glasgow, and was launched the 3rd July, 1855; her extreme length is 389 feet; breadth 45 feet, and over the paddle-boxes 71 feet 6 inches, and her depth 31 feet 6 inches. She is fitted with side-lever engines of 850 horse-power; cylinders 100½ inches diameter, with a stroke of 10 feet; she has eight boilers, with five furnaces in each; and her paddle-wheels are 38 feet 6 inches diameter, the floats being 10 feet 8 inches by 2 feet, and 28 in number. She carries 1,200 tons of coal, and her displacement at 22 feet draught is 5,400 tons.

The 'Scotia' is a sister-ship, but a little larger.

Then we have the superb fleet of the Peninsular and Oriental Company—the 'Pera,' 'Ceylon,' 'Massilia,' 'Delta,' 'Simla;' and for this Company also was built the magnificent screw-steamer 'Himalaya,' by Messrs. C. J. Mare and Co., in 1853; her extreme length being 372 feet; breadth for tonnage 46 feet 2 inches, and depth of hold 24 feet 9 inches; she is fitted with horizontal-trunk engines, by Messrs. J. Penn and Son; cylinder 84 inches diameter, and 3 feet 6 inches stroke; her propeller is 18 feet diameter, and 28 feet pitch. She was purchased by Government for a transport ship during the Crimean war, and on one occasion she conveyed 418 troops and 372 horses from Liverpool to Constantinople, a distance of 3,620 miles in a little over 14 days, although she partly lay-to from stress of weather between Cape St. Vincent and Gibraltar.

We now arrive at a period in the history of steam navigation to which it is impossible to refer without a passing word of reflection. In the beginning of this article we spoke of the extraordinary enterprises that Man has from time to time undertaken, as it were, by inspiration; and if, in this respect, there be one more marked than any other, illustrating at the same time the active restlessness of his reasoning nature, it is the undertaking we have now to record, namely, the construction of the 'Leviathan,' or, as she is at present called, the 'Great Eastern.'

In days of yore, the "wonders of the world" presented indelible records of Man's superstition, of his artistic taste, and of his prowess in war; and we have surviving to the present time the Sphinx, the ruins of beautiful temples, the Great Wall of China, &c.; all enterprises of the same essential nature. The construction of the 'Leviathan' is, however, not only characteristic of the great attribute of our age, namely, utilitarian enterprise, but it has developed the minds of men in a new direction, and thus led to a greatly-extended application of the physical forces. The origin of the idea which led to the building of the great ship was this:—

All the steamers to which reference has been made, great as they were, could not carry sufficient coal for a very long voyage without deviating so much from the direct route to obtain fresh supplies of fuel at the coaling stations, as to greatly lengthen the voyage; thus in steaming round the Cape to India or Australia they would have to call at St. Vincent, the Cape of Good Hope, and the Mauritius, to obtain coal, which had to be sent out to those places. Hence steamers which have accomplished the voyage to Australia in a very short time have lost immense sums of money through the ruinous price of fuel at these stations, in spite of their having both a full cargo and complement of passengers; and in extra long voyages fast-sailing clippers have altogether beaten the steamers, inasmuch as they have effected the passage to Australia in quite as short time as the fastest steamers.

Brunel therefore proposed that a ship should be built of such dimensions as would enable her to carry sufficient coal for the longest voyage; and as the cost of this coal at home would be about one-third of the average price paid on the voyage to Australia for ordinary steamers, she would be worked with far greater economy than other boats, besides making the voyage in a much shorter period. It was with this object that the 'Great Eastern' was projected.

This gigantic vessel was constructed by Mr. John Scott Russell, under the superintendence and direction of Mr. Brunel; her principal dimensions being 691 feet extreme length; 680 feet between the perpendiculars; breadth across paddle-boxes, 118 feet; breadth of hull, 83 feet; depth, 58 feet; and her tonnage by the old measurement, 22,500 tons; she has stowage for 6,000 tons of cargo, and her coal-bunkers will hold 12,000 tons. She is built on what is termed the cellular principle, being similar in construction to the tubes of the Menai Bridge, so that she is virtually a double ship, or one vessel placed inside of another, with partitions running fore and aft between her two "skins." She is divided into twelve water-tight compartments, and the weight of iron in the hull is 8,000 tons. She is propelled by a combination of paddle-wheels and screw. The engines for working the paddles consist of four oscillating cylinders 74 inches diameter and 14 feet stroke, each cylinder complete weighing 38 tons; they are of 1,000 nominal, or 3,538 indicated horse-power. The paddle-wheels are 56 feet diameter, and the floats are 13 feet by 3 feet, and 30 in number. The screw-engines consist also of four cylinders 86 inches diameter and 4 feet stroke, and are of 1,600 nominal, or 4,610 indicated horse-power; the screw is 24 feet diameter, and 44 feet pitch. The boilers for this stupendous machinery are ten in number, each boiler weighing upwards of 50 tons; four of them drive the paddle-engine, and six the screw. She has also powerful auxiliary engines for turning the screw when under sail, and has no less than ten donkey-engines for pumping, and for various other purposes.

She possesses accommodation for 800 first-class passengers, 2,000 second-class, and 1,200 third-class; and her principal saloon is 100 feet long, 36 feet wide, and 13 feet high. The consumption of coal amounts to $12\frac{1}{4}$ tons per hour, and the greatest speed by paddles and screw separately is as follows:—Paddles alone, 8 knots; screw alone, 9 knots; giving the screw a decided preference over the paddles. The cubic feet in paddle engine-room, including boiler space, is 116,000; and the cubic feet in the screw engine-room, including boiler space, is 112,000; mean draught of water, 23 feet $8\frac{1}{2}$ inches; mean effective diameter of paddles, 48 feet $7\frac{3}{4}$ inches; mean slip of paddles, 17·4 per cent.; mean slip of screw, 17·9 per cent.; mean consumption of coal per hour, $12\frac{1}{4}$ tons; mean miles per hour, $14\frac{1}{113}$; coal consumed per indicated horse-power, $3\frac{1}{2}$ lbs.; ditto per nominal horse-power, $11\frac{1}{8}$ lbs.; greatest distance run in 24 hours, 360 miles; mean revolution of paddles per minute, $10\frac{3}{4}$; of screw, $36\frac{3}{4}$; mean displacement, $19{,}273\frac{1}{2}$ tons; or, with 5,000 tons of coals on board at 24 feet 10 inches draught, 20,940 tons.

As a specimen of expert workmanship and strength the 'Great Eastern' has never been excelled.

The following particulars of length and beam of some of the principal transatlantic and war steamers will give a general idea of the size of the monster steamer last alluded to.

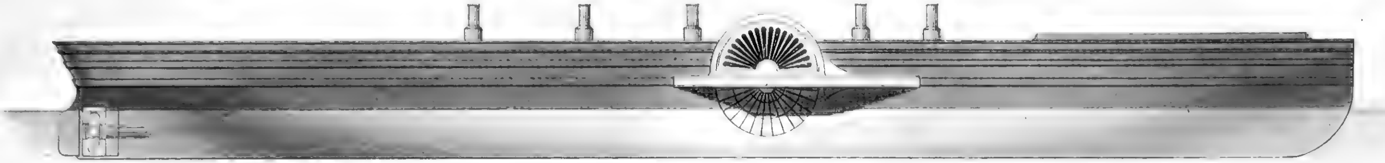
Comparative Dimensions of a few of the Largest Steamers.

	Built.		Length.	Breadth.
Great Western	1838	First Atlantic steamer	236	36
Great Britain	1844	First Ocean screw steamer	322	51
Himalaya	1853		372	46
Persia	1856		390	45
Duke of Wellington	1855	First-rate line-of-battle ship	240	60
Warrior	1861	Iron-plated frigate	380	58
Great Eastern	1858		680	83

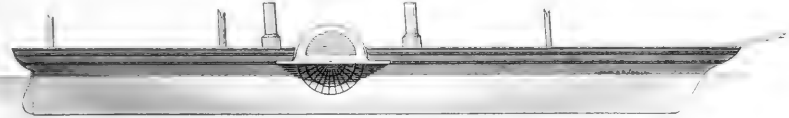
In order, however, more fully to illustrate the great difference in size between the first successful transatlantic steamer, the 'Great Western,' and the last, the 'Great Eastern,' as well as to afford some idea of the intermediate steps in the progress of steam navigation, the accompanying plate will be of some service. It exhibits also the difference in the general construction of the hull of the vessels; the smaller 'midship section representing the usual system of construction, and the larger one showing the cellular method adopted in the 'Great Eastern.'

Being the largest steamer afloat, we have felt ourselves justified in entering rather more fully into the details of the construction of the 'Great Eastern,'—the more so as it is probable that she will remain unrivalled for many years to come. Independently of her size, she is throughout one of the finest specimens of naval architecture and mechanical genius extant, doing credit alike to her constructor and designer. The 'Great Eastern,' in common with many of the works of Mr. Brunel, is rather an illustration of the talent and energy which can be brought to bear upon mechanical science than, so far, a success from a mercantile point of view; in fact, Mr. Brunel has throughout the whole of his life been an example of genius without practical results. We have only to look at the various works executed by his father and himself to exemplify this; the Thames Tunnel to wit, the Great Western Railway works, the Box Tunnel, the Harbro' cutting, and last, though not least, the Great Eastern, a scientific success, but so far a mercantile failure. This vessel is so much in advance of the age and the conveniences which it affords, and the expenses in case of repair from damage or otherwise are necessarily so exorbitant, that few if any speculators can be found to embark a considerable amount of capital in her as an investment. There is no wet or dry dock at present in existence sufficiently large to admit her; consequently, when the most ordinary repairs are necessary, and even when the vessel requires painting, she has to be laid aground, and from the peculiarity of her form, having no keel, (as will be seen from the accompanying sketch,) it is impossible to get to her bottom without excavating the ground from beneath her. The expenses of loading and unloading too, are serious items in the working of so large a ship, and can only be compensated by long voyages; for what may be called

GREAT EASTERN

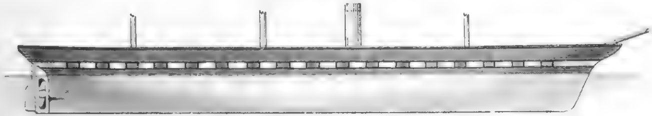


PERSIA

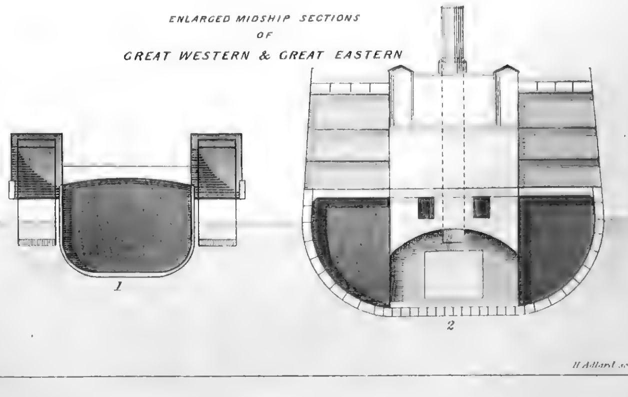


	LENGTH	BREADTH	DEPTH	HORSE POWER	LAUNCHED
GREAT WESTERN	212	35	23	400	1837
GREAT BRITAIN	286	50	32	500	1843
PERSIA	360	45	33	850	1855
GREAT EASTERN	680	83	58	2800	1858

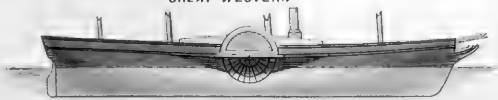
GREAT BRITAIN



ENLARGED MIDSHIP SECTIONS
OF
GREAT WESTERN & GREAT EASTERN



GREAT WESTERN



J. Humphrys del. H. Adlard sc.

her terminal expenses would thus be only incurred at longer intervals than in short voyages. As we progress, however, in the construction of docks and other necessary naval works, they will no doubt be so enlarged and by degrees be of such a class as to admit a vessel the size of, or even larger than the 'Great Eastern;' for we fully believe that we are not yet at the extreme limit of size: another quarter of a century will, in our opinion, see vessels of even a larger tonnage than the 'Great Eastern' afloat. This will, however, take many years, and in the meantime the precursors of enlarged views have had to pay the penalty of their hardihood, as was the case in a minor degree with reference to the steamer 'Enterprise' before alluded to.

Of the ultimate commercial success of the 'Great Eastern' we entertain no doubt whatever, but this can only be realized by what may be termed single-handed enterprise, and through her employment on a long voyage, such as that to Australia or India. It will be dependent too upon a modification in the propelling power of the vessel, as well as upon the price at which she can now be obtained. In January last this magnificent ship was put up to public auction by the mortgagees, and although a reserve price of only 130,000*l.* was placed upon her, the highest bid was 50,000*l.* Probably before these pages go to press she may have been sold without reserve for a sum under 100,000*l.*;* and it is only when we recollect that she originally cost above three quarters of a million of money, that we are able to realize the terrible sacrifice which has been made by the present proprietors. Much honour and credit is, however, due to those whose enterprise induced them to embark in the speculation in the first instance, and who thereby rendered patent to the world the feasibility of constructing a vessel of dimensions so much greater than any previous attempt in naval architecture.

It will be easy now for those who have witnessed the failure in a mercantile sense to come forward and profit by the experience of the past, and to remedy those defects or errors which rendered the speculation so ruinous in the first instance; and probably the first step which will be taken when the vessel changes hands, will be to remove the paddle engines and alter her rig. For it will be seen from the foregoing statements that although her speed is increased by the application of the paddle and screw engines combined, it is not commensurate with the expense at which such additional speed is acquired. When the paddles alone are employed, a mean speed of 8 knots is obtained; and with screw and paddle combined, 14 knots under the most favourable circumstances; whereas the vessel will make 9 knots per hour with the screw engines alone.

The saving in one important item of expenditure—namely, fuel—would be so considerable, and the change, if it were effected, would so

* Whilst this article is passing through the press, we are apprised that the 'Great Eastern' was "knocked down" for 25,000*l.*, and a new company, of which Mr. Thomas Brassey, jun., is the leading director, advertises that it has purchased the vessel, and the bonds upon her inclusive, for 97,350*l.*; this new company having been the purchasers of her at auction. A dispute has, however, arisen as to who is the rightful owner, another bidder having put in a claim to her.

obviously constitute the difference between a commercial failure and a pecuniary success, that it appears hardly necessary for us to enter into minute details. It is easy to calculate that with her screw alone at work, the 12,000 tons of coals which she carried would nearly suffice for a 70 days' voyage, but the most striking and at the same time familiar mode of exhibiting the enormous advantages which she would thus possess over any existing transatlantic paddle boat, will be to compare her, under her new conditions, with the 'Persia,' showing the relative consumption of fuel and the carrying capacity of each steamer.

With her paddle engines removed, the 'Great Eastern' would carry about 7,400 tons of measurement goods, and 12,000 tons of coal (more cargo and less coal in proportion). She would burn about 200 tons of coal per diem, and steam 9 knots per hour. The 'Persia' carries 1,257 tons of measurement goods, and 1,700 tons of coal, and, burning about 150 tons per day, attains an average speed of 12 knots per hour. Thus, if we were to take into consideration the increased speed attained by the 'Persia' over the 'Great Eastern,' we should have to take the quasi-consumption of the latter, not at 200, but at 260 tons per day.*

Now let us compare the work as it would be performed by the two boats, with the coal required by each, and we shall find that,—

The 'PERSIA,' carrying 1,257 tons of goods, and consuming 150 tons coal per day, burns 270 lbs. of coal per day for every ton of goods carried by her.

Whilst the 'GREAT EASTERN,' carrying 7,400 tons of goods, and consuming 268 tons of coal per day, would only burn 81 lbs. of coal per day for every ton of goods carried.

This comparative statement exhibits in a general manner how great is the advantage of a screw over a paddle steamer for trading purposes, but as far as the 'Great Eastern' is concerned, we do not hesitate to say that with appropriate internal arrangements she could be made to carry at least 10,000 tons of measurement goods; that with the screw alone and a suitable rig, she would, in an average state of the weather, attain a speed of 10 knots an hour; whilst with a good wind she would keep pace with, if not outstrip, the fastest paddle steamer afloat. A comparison of the transatlantic mail paddle boats, supported by a subsidy, with the screw boats in the same service not so endowed, would further confirm the statement of the superior economy of the screw.

Once more, too, we would repeat that, instead of believing, with many, that her designer and builder have exceeded the legitimate dimensions of a manageable steam-vessel, we hold that not a few of

* Throughout this paper we have avoided technical details which might be obscure to the general reader; but we think it right here to say, that in this comparison between the 'Great Eastern,' without paddle engines, and the 'Persia,' we have duly considered the difference between an increase of cargo and the weight of the engines removed; also the bearing of the greater size and weight of the 'Great Eastern,' in relation to her locomotive power; the "lively" nature of cargo, compared with the dead weight of the engines removed; and the antagonistic action between paddle and screw; but we have only given our deductions in general terms.

our readers will live to see steamers of much larger proportions; and most confidently do we predict a brighter future for the noble vessel now lying idle in the river Mersey.

It has been impossible, in the limited space at our disposal, to give even a tolerably perfect sketch of the progress of steam navigation; but in order to afford our readers some idea of the vast mercantile steam navy that has been called into existence through the insatiable demands of commerce, we may mention that there are at present employed upon one great Ocean route alone, namely, from Liverpool and Glasgow to the continent of North America, 100,000 tons of steam shipping, all created, in addition to vessels that have been lost, since the 'Great Western' was launched; and that there is furthermore a large fleet of additional steamers now in course of construction.

But we have thus far spoken only of our mercantile steam navy, and have said nothing concerning the armaments of our country.

It is indeed unnecessary that we should do so. That governments are slow to move, and that ours did not follow in the wake of the merchant service with any great alacrity, is well known to our readers. They are aware also that having once commenced, the Admiralty added year by year to our steam fleet; and we may say without boasting that in both services we have outstripped our neighbours as completely as when wooden walls protected old England.

But we pass over this portion of the subject without regret or apology, quite content to leave its treatment to other and abler pens than ours.

We have endeavoured to render as intelligible as it is possible for one accustomed rather to building, than to writing about steamers, the theme with which we have been called upon to deal; and have only to remark, in conclusion, that *our* industry was not originated for warlike purposes, although it was afterwards thus applied, or we should rather say misapplied; for had the first steam-boat been endowed with life and speech, we are sure that her earliest sentences would not have been those of anger or defiance, but that she would have proclaimed, as did later the Atlantic telegraph, "Glory to God in the highest, on earth peace and good-will towards men."

NOTE.—Much additional and interesting information on the subject of Steam Navigation will be found in 'Steinitz's History of the Ship' (Longmans), and Captain Claxton's Pamphlet on the 'Great Britain.' We have to acknowledge our obligations to John Scott Russell, Esq., to the owners of some of the trans-atlantic steamers, to Henry A. Bright, Esq. (Messrs. Gibbs, Bright, and Co., owners of the 'Great Britain'), and to many other friends, for valuable information supplied to us.

THE FOSSIL SKULL CONTROVERSY.

ON HUMAN CRANIA ALLIED IN ANATOMICAL CHARACTERS TO THE ENGIS AND NEANDERTHAL SKULLS.

By William Turner, M.B., F.R.S.E., Senior Demonstrator of Anatomy in the University of Edinburgh.

Of the various crania which during the last few years have come under the notice of the geologist and anatomist, few, perhaps, have excited so much interest as those fragments of two human skulls which, from the localities where they were found, have been named the Engis and Neanderthal skulls. The lengthened descriptions given of them in the recent works of Sir C. Lyell 'On the Antiquity of Man,' and of Professor Huxley 'On Man's Place in Nature,' and the light which they have been supposed to cast on the solution of the great problem of the antiquity of the human race, have caused a large amount of attention to be directed to them. Not only have the various circumstances connected with their discovery, the geological conditions under which they were found, and their association or non-association with various animal bones, been carefully noted, but their shape, proportions, and general anatomical characters have been minutely studied.

The Engis Cranium.

This skull was discovered by the persevering researches of Dr. Schmerling in the Engis cave, in the province of Liège, in Belgium. It was found with other fragments of human bones, covered by a layer of stalagmite, and along with it were imbedded the bones of various extinct animals, as the mammoth, the woolly rhinoceros, and the cave bear. Dr. Schmerling regarded it as cotemporaneous with those animals, and from independent researches into the geological relations of the locality, the same opinion has been arrived at by Sir C. Lyell.

The skull is a fragment, but the vault of the cranium is preserved. It is to all appearance that of an adult male. Mr. Huxley has carefully described and figured it in both the works above referred to, and has come to the following conclusions respecting it. That there is nothing in its character to give any trustworthy clue to the Race to which it might appertain, for though some of its contours and measurements agree well with some Australian skulls, yet others agree equally well with some European crania; that there is no mark of degradation about it; that it is a fair average human skull, which might have belonged to a philosopher, or might have contained the thoughtless brains of a savage.

The skull with which I am going to compare it was sent to the Anatomical Museum of the University of Edinburgh some months back by Mr. Henry Duckworth, F.G.S. It was found by him in the summer of 1861, when on a visit to St. Acheuil, near Amiens. "It lay about six feet from the surface, in a deposit termed by the quarrymen the 'Découvert' bed, which deposit appeared like a narrow vein or band of marly sand and small flints, dividing, at an angle of say 45°, the vegetable or brick earth on one side from the black flint deposit on the other." As various remains of the Roman and Gallo-Roman age have been found in this locality, it is possible that the skull may be as old as that period, but there is no evidence that it belonged to an earlier time. The skull is a fragment, but possesses almost the same bones as the Engis cranium. It is the skull of an adult, and from its faintly-marked ridges and supra-orbital processes is either a female, or a male whose muscular development was feeble. The bones possess no unusual thickness or density, such as one not unfrequently sees in the crania of savage nations. They are, however, somewhat friable, of a pale yellowish-brown colour, and much deprived of their animal matter. Numerous linear excavations due to the action of the roots of the plants in the soil are on their outer surface.* The different regions of the cranium are well proportioned to each other, and there are no marks of degradation about it. The strong resemblance in external form between this cranium from St. Acheuil and the Engis skull at once struck me, and careful comparative measurements have confirmed my first impressions. The Engis skull is, indeed, somewhat larger, but the proportions between the corresponding parts of the two crania are closely preserved.†

SKULL.	Length.	Frontal Breadth.	Parietal Breadth.	Occipital Breadth.	Longitudinal Arc.	Intermeatoid Arc.	Hor. Circumference.
Engis . .	7·7	4·4	5·4	4·4	13·75	13·	20·7
St. Acheuil .	7·1	4·1	5·1	4·1	12·2	11·8	19·6

The length of the Engis skull is to its breadth as 100 to 70, that of the St. Acheuil cranium as 100 to 71. If my supposition be correct that the latter is a female, the difference in size may, perhaps, be regarded as merely a sexual difference. The St. Acheuil skull is somewhat more convex posteriorly in its upper occipital region; but, as a rule, the contours of the two crania so closely resemble each other, that one might almost look upon the one from St. Acheuil as a reduced copy of the Engis skull.‡

* The interpretation of this appearance was made for me by my friend, Professor Rolleston, of Oxford; and since my attention was directed to it, I have not unfrequently noted a corresponding appearance in bones which have been buried at no great distance from the surface.

† The measurements of the Engis skull have been taken from a cast supplied by Mr. Gregory, of Golden Square, London.

‡ A minor structural difference consists in the presence of a small triquetral or inter-parietal bone in the St. Acheuil cranium; but such a bone, although at one time supposed to possess, is now known to have no especial value as an index of race character. I have, for example, seen it in two Australian crania, in a Malay, a Hindoo, a North American Indian, a Chilian Indian, a Ceylonese, a Scotch, and a French cranium. It can no longer be regarded as a distinctive peculiarity of the Peruvian skull.

A question of much interest at once suggests itself by this comparison. Are we to regard the occupant of the Belgian cavern as of the same race as the dweller on the banks of the Somme? The geographical distance between the two localities is not great, but the geological distance as regards time between the cotemporary of the mammoth and woolly rhinoceros and the inhabitant of the North of France at a period not more remote than the Gallo-Roman age is, as all present evidence indicates, indeed enormous. The answer to the above question, then, will doubtless be regulated by the opinion which may be entertained of the value of cranial characters, as an element in ethnical comparison. Many ethnologists of eminence consider, and with much reason, the form of the skull as one of the most important tests to be employed in determining the affinities of races, for the crania of individuals of the same race possess a strong general resemblance throughout long periods of time. But whatever opinion may be formed of the identity or non-identity as regards race of the two individuals to whom these crania belonged, there can, I think, be no doubt that, as this skull from St. Acheuil proves, the cranial conformation, and presumably the cerebral conformation also, of the geologically ancient Belgian was in no respect inferior to this inhabitant of France during a period in its history not more distant than the Gallo-Roman time.

The Neanderthal Skull.

The circumstances connected with the discovery of this cranium have been so well detailed by Dr. Fuhlrott, Professor Schaaffhausen, and Sir C. Lyell, and its anatomical characters have been so carefully described and figured by Professor Schaaffhausen, Mr. Busk, and Mr. Huxley, that it is needless for me to enter into any detailed description of them, more especially since Professor King has already placed many of the most important facts connected with it before the readers of this Journal in the number for January. My object will be sufficiently carried out if I especially discuss those features in its structure which either are, or are supposed to be, its peculiar characteristics, and which are considered to distinguish it from all other known human crania.

The skull, when looked at even by one not skilled in human anatomy, is seen to possess remarkable features. The flattened vertex, the low retreating forehead and strongly projecting supra-orbital ridges, at once attract attention, and show that it is an exceptional form of human cranium. To these more obvious characters Mr. Huxley has added yet another, in the shape of the occipital region, which he looks upon as even more striking to the anatomical eye.

The consideration of these peculiarities, together with some others of minor importance, has led Professor King to look upon the being to whom this cranium belonged as specifically, nay more, as generically, distinct from man. But in coming to this conclusion, that observer appears to me to have estimated far too lightly the amount of variation to which the human body is subject, in the structure and arrangement of its constituent parts. I allude not merely to divergences in the conformation of corresponding parts of the bodies of men of different races, but of individuals of the same race; variations which, though they may be great enough to constitute large and important individual differences, are still not sufficient to warrant our assuming the absence of those characters which are especially and distinctively human. I refer not only to those variations in the form of the features, the colour of the skin, and the nature of the hair, which are discernible on an external examination of the body, but to those deeper or internal differences affecting the origin and distribution of the blood-vessels, the extent of attachment of the muscles, the non-formation in some cases of muscles usually present, and in other cases the development of new muscles. Similarly, the bones themselves may exhibit great variations in the size of their ridges and processes; and in some individuals processes may even occur which do not generally enter into the formation of the human skeleton.* All these afford illustrations of such a great amount of variability as to cause the careful human anatomist to hesitate, if an unusual structure or arrangement in a part evidently human were shown him, before he ventured to pronounce such structure or arrangement to be an indication that the being in whom it occurred was either a distinct species of man, or a form transitional between man and the lower animals.

The Neanderthal skull unquestionably possesses a very remarkable shape, one which sufficiently distinguishes it from other known crania. But we must inquire whether its anatomical characters are altogether exceptional. Is it not possible, in carefully examining an extensive collection of skulls, such as are presented to the anatomist in a large museum or dissecting-room, to find crania closely allied to it in some of those features which are regarded as most distinctive? I have, during the past year, directed much attention to this matter, and have examined numerous crania, both of savage and European nations. The points in the Neanderthal skull which I have most closely compared with other crania, have been—1st, the projection of the supra-orbital ridges and glabella; 2nd, the receding forehead; 3rd, the shape of the occipital region.

The supra-orbital ridges in the Neanderthal skull are characterized not only by their great projection forward, but by their rounded massive form. They extend outwards as far as the external orbital processes, and they run into each other across the middle line at the prominent glabella. Their extent and projection, as is clearly shown in the figure (from a photograph by Dr. Fuhlrott) in Mr. Huxley's work, are due to the excessive development of the frontal sinuses.†

* It may be sufficient to mention here the occasional development on the occipital bone of an additional process called paramastoid, and of a process, the supra-condyloid, springing from the humerus a short distance above the inner condyle. An elaborate description of all the different forms which the latter process presents in Man and a comparison of their arrangement in certain of the Mammalia, as in many Quadrumana, Carnivora, Marsupialia, &c., is given by Gruber, in the 'Mém. de l'Acad. Imp. de St. Pétersbourg,' vol. viii. 1859.

† These sinuses are cavities in the frontal bone due to a want of parallelism between the two plates, of which the bone is constructed. They contain air, and communicate with the nose.

In attempting, however, to form a correct estimate of this projection, it is necessary to bear in mind that the absence of the bones of the face, more especially of the nasal, malar, and upper jaw bones, tends to give a more marked character to it than would probably have been the case had they been present.

Professor Schaaffhausen, in his remarks on this skull, states that in the principal European museums there are no crania which can be compared with it in the amount of this supra-orbital projection; but he refers to various craniological memoirs, in which cases have been recorded of a considerable, though not so great a projection in this region, more particularly in the skulls of ancient and modern barbarous races. Mr. Huxley also, in his critical account of this cranium, alludes to the supra-orbital projection in Australian skulls, though this is not unfrequently due to a solid bony growth, the frontal sinuses being undeveloped. Mr. Busk has also figured the cranium of a red Indian,* and a skull from Borreby, in Denmark, stated to be of the Stone period, in which these ridges project considerably. In the Ethnological collection in the Anatomical Museum of the University of Edinburgh, are also several crania, in which they constitute a striking feature. Some of the New Zealand and Tasmania crania, for example, are cases in point. But this character is by no means confined, as it appears to have been far too generally believed, either to the crania of modern savage races, or to those former denizens of these islands and of continental Europe, the men of the Stone period, of the age of Iron or of Bronze. It is a character which occasionally crops out, as it were, not only in the men, but the women even, of the British Islands at the present day, and at times attains a prominence which, though not quite equalling, yet is but little removed from that in the Neanderthal skull. I have now† before me three modern British crania, and the cast of a fourth (Fig 1) in the Museum of the College of Surgeons of Edinburgh (No. 34), in which it may be studied. In the whole of these skulls, the prominence of the glabella and supra-orbital ridges is most strikingly marked, especially in the extent to which they project forward, though none of them exhibit so massive a form at the external orbital processes as the Neanderthal skull. In two of the crania more particularly (one of which is that of an old woman, Fig 2), there is a deep depression at the root of the nose, such as to all appearance the Neanderthal skull possessed when in its perfect state.

The low retreating forehead is a character which presents much variety in human crania In the one from the Neander valley it is considerable; but as Mr. Huxley has remarked, the supra-orbital projection causes the forehead to appear still lower and more retreating than it really is. But what the true slope of the forehead may have been, there is now some difficulty in accurately determining, on account of the fragmentary nature of the skull, rendering it difficult to say what was the true position of the head. The influence which a change in the position of the head exercises on the slope of the forehead, either in adding to or sub-

* 'Nat. Hist. Review,' vol. i. pl. v.

† The figures refer to the accompanying plate.

tracting from it, is illustrated by the different appearance it presents in the figures of this cranium given by Sir C. Lyell and Mr. Huxley. I have now before me a modern British skull which closely approaches it, nay, is rather more flattened in the frontal region on account of the very faintly marked condition of the frontal eminences. I may refer here also to a fragment of a skull, perhaps that of an old monk, in the collection of Christ Church, Oxford (shown me by Professor Rolleston), and to the cast of the cranium of Archbishop Dunbar (obiit 1547), in the Museum of the Scottish Society of Antiquaries, in both of which there is a remarkably flattened and retreating forehead.

Professor King lays great stress upon the coexistence of the projecting supra-orbital ridges and retreating forehead in the Neanderthal skull; more especially with regard to the part of the frontal bone, which is intersected by a line drawn at right angles to the glabello-occipital line through the infero-anterior angles of the two outer orbital processes. I cannot but think that if Professor King, instead of selecting for his comparison such a recent human skull as the one he figures in Plate 2, Fig. 5,* had taken a human skull presenting in combination a retreating forehead and projecting ridges (such as represented in Fig. 1), he would have found that no great difference existed between it and the Neanderthal skull in the amount of frontal bone cut off by such a line.

I have already stated that Professor Huxley attaches much importance to the shape of the Neanderthal skull in its occipital region. He describes the squamous part of the occipital bone as sloping obliquely upward and forward from the protuberance and superior curved line, so that when the glabello-occipital line is made horizontal, the occipital protuberance occupies the extreme posterior end of the skull, and the lambdoidal suture is situated well on the upper surface of the cranium; as a result of which the posterior lobe of the brain would have been flattened and diminished.

But if this mode of description be adopted, it must be borne in mind that the upward and forward slope is not that of a plane surface. For the squamous plate of the bone possesses a curved surface with the convexity projecting backwards and upwards, though this convexity is undoubtedly much smaller than the greater majority of well-formed crania exhibit. Then again I find, from measurements of the cast of this skull, that the greatest antero-posterior diameter is not included in a line drawn between the glabella and occipital protuberance, but in a line drawn from the glabella to a point in the squamous part of the occiput, about half-an-inch above the protuberance; though whether this point may in this individual have been the most projecting part of the head posteriorly, it is impossible to say, on account of the difficulty of placing this fragment of a skull in its natural position.

But to follow out the method which we have hitherto pursued in this investigation, let us now, by a comparison of this part of the Neanderthal skull with the corresponding region in other human

* Jan. No. 'Quarterly Journal of Science.'

crania, see what value is to be attached to its configuration as an especial character. Messrs. Busk and Huxley have already shown, that in the Danish Borreby skull, and in some Australian crania, the occipital region presents a form closely allied to the Neanderthal skull itself. Additional evidence of this correspondence is supplied by the Australian and Tasmanian crania in the Edinburgh University Anatomical Museum, in one of the former of which the squamous plate is nearly flat, and forms almost a right angle with the surface of the bone below the curved line. But it is not with these savage races only that this comparison can be made. An examination of a considerable number of modern British crania has shown me that a large amount of variation occurs in them in the form of this region, and in the extent of the posterior convexity of the squamous part of the occipital bone. And it would be quite possible to arrange, from materials to which I have access, a series of modern British skulls, in which this variation may be traced from a well-marked posterior occipital bulging to a configuration of the upper occipital region, closely approaching the form of the Neanderthal skull. In the skull-cap represented in Fig. 3, the diminished occipital convexity is almost equal to that of the last-named cranium.*

Professor Schaaffhausen regards the unusual development of the frontal sinuses, supra-orbital ridges, and glabella, as unquestionably typical race-characters, and not as an individual or pathological deformity. To accept such a view, however, it would be necessary to show that a great projection in the supra-orbital region possesses a definite ethnical value. But this, I would submit, is an inconstant feature, for great variations in the size of these ridges are exhibited by the crania of barbarous races, both ancient and modern, in which such projections have been seen. The series of New Zealand, Australian, and Negro crania, in the Ethnological Collection in the Edinburgh University Anatomical Museum, exhibits considerable diversities in this respect. Again, in the beautifully illustrated 'Crania Britannica' of Messrs. Davies and Thurnham, whilst some of the ancient British crania depicted present a considerable projection above the orbits, in others, again, it is but slightly marked.† And as we all know that no great prominence occurs as a rule in the modern British skull, yet, as the specimens already alluded to (p. 254) prove, an amount of projection may occasionally occur not much inferior to that in the Neanderthal skull.

To attempt, then, to found, as Schaaffhausen has done, a typical race-character on so variable a feature, or to build a chief argument in favour of the distinct specific, nay even generic, character of a skull, as Professor King has done, on a solitary cranium in which such largely-developed supra-orbital ridges occur, does not appear to me to be warranted by the facts at our disposal. Mere massiveness—the

* In the University Anatomical Museum is the skull (B. 5) of a modern patriotic Greek, picked up on the plain between Athens and the Piræus, in which this configuration of the occipital region is most strikingly marked.

† Compare, for example, the Ballidon Moor, Uley, and Kennet crania with those from Middleton Moor, Long Lowe, and Littleton Drew.

possession of greater bulk in this region in an individual skull—is not in itself a feature on which to base any specific distinction. As well might we attempt to draw specific characters from a greater or less development of the mastoid processes. To give anything like value to such a character, it ought to be shown to be possessed by the majority at least of the skulls of a given race Keeping in view, then, the amount of variation which this projection admits of in the crania of known races, and in the absence of any skulls cotemporaneous with the one from the Neanderthal with which to compare it, we should hesitate before expressing an opinion that it is an ethnical rather than an individual character.

Amongst the various speculations which have been hazarded, as to the nature and mental capabilities of the man to whom this singular skull appertained, there is one expressed in the inquiry, "But may he not have been an idiot?" In the absence of any definite information, it is alike impossible to prove either that he was an idiot or a sane person. I have, however, compared the skull with the crania of three idiots, and find not only considerable diversities between its form and theirs, but in the form which the idiot cranium itself may present. In one of the idiot's skulls the forehead is low and retreating, and the supra-orbital ridges are large, but the external measurements and internal capacity are so small as to place it amongst the microcephali. Now the Neanderthal skull cannot be regarded as microcephalic, either in its external measurement or internal capacity. It possesses an extreme length of 8 inches when measured from the glabella to the most projecting point of the occiput, and of 7·2 when the measurement is taken between the frontal eminences and the corresponding occipital eminences, which latter diameter is of greater value than the former as an index of cranial capacity, because it eliminates the supra-orbital projection and frontal sinuses. Its greatest breadth is 5·9 inches. Its present capacity is 63 cubic inches; but its capacity in the original condition is estimated by Mr. Huxley at 75 cubic inches, which is the average capacity given by Morton for Polynesian and Hottentot skulls.

Amongst modern European crania, the average cranial capacity is considerably higher than this. Professor Welcker, of Halle,* from careful measurements of 30 normal, male, adult German crania, has placed the mean capacity at 88·4 cubic inches. But whilst the maximum of these crania rose as high as 109 cubic inches, the minimum sank as low as 74·4 cubic inches, a capacity scarcely so great as the estimate made of the Neanderthal skull; and the capacity of two others was only 78 and 78·6 cubic inches. Again, Professor Huschke,† from the measurements of 21 male German crania, has found their average capacity to be 88·17 cubic inches; but the smallest of these skulls was no more than 73·1 cubic inches, which is nearly two cubic inches smaller than the Neanderthal skull. Thus though the estimated capacity of this cranium is less than the

* 'Untersuchungen ueber Wachsthum und Bau des Menschl. Schaedels,' 1862, p. 35.

† Schaedel, Hirn, und Seele, 1854, p. 47.

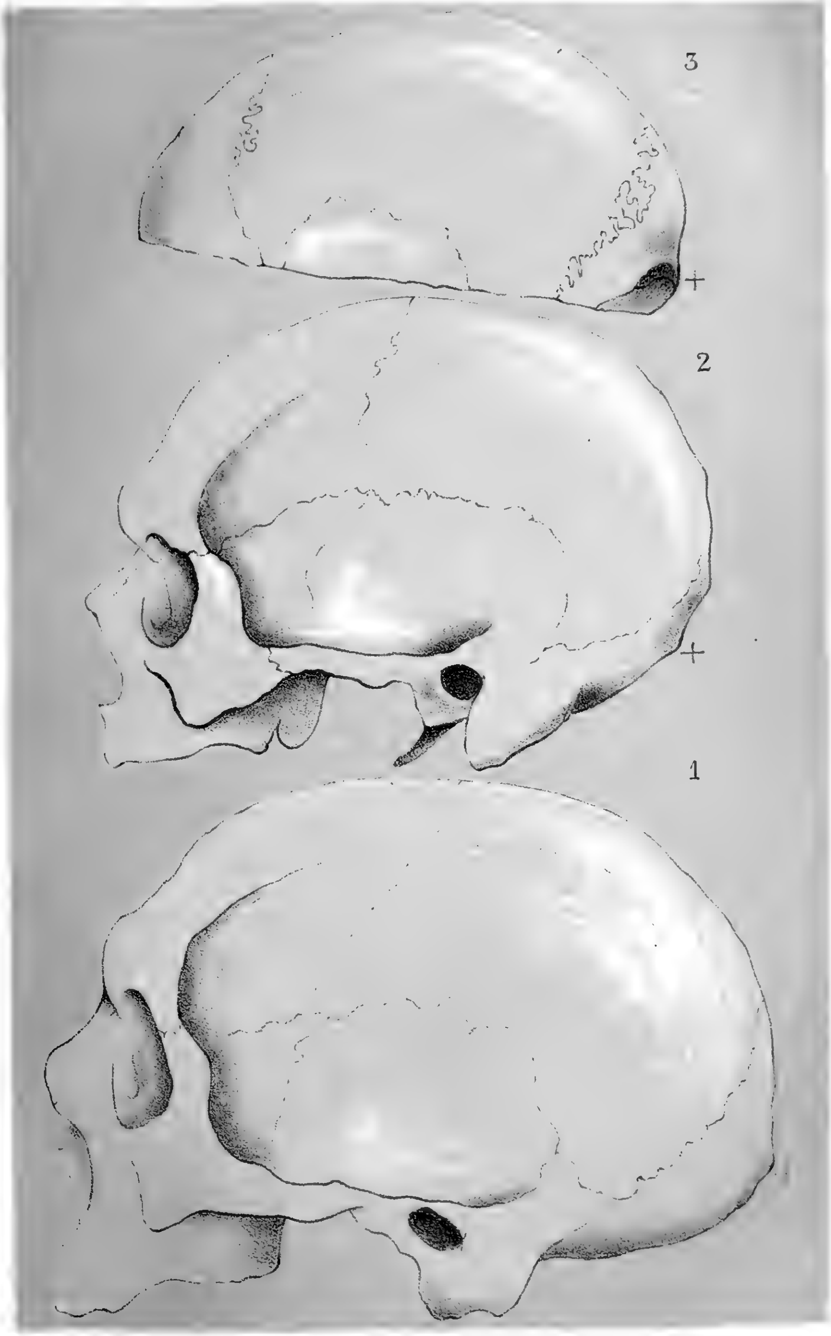
European mean, yet modern male German crania have been measured, which closely approach, and even sink below it. The possession of strong supra-orbital ridges, a low retreating forehead, and a diminished occipital convexity, is not therefore necessarily incompatible with an amount of brain space larger than that yielded by some modern European crania (which such experienced craniologists as Huschke and Welcker looked upon as normal), if the space lost in the frontal and occipital regions is compensated for by increased growth in another direction. And in the Neanderthal skull this compensation appears to have been provided in the parietal region, which is nearly three-tenths of an inch wider than that given by Mr. Busk as the mean breadth of the European skull.* But the skull, No. 34, Edinburgh College of Surgeons' Museum (Fig. 1), yields us still more striking testimony of the occasional co-existence even of enormous cranial capacity with projecting supra-orbital ridges, a low forehead, and diminished occipital convexity. Its capacity is 117 cubic inches, which is three cubic inches greater than that of the most capacious skull I can find recorded.† And like the Neanderthal, it has its greatest breadth close to the squamous suture, and not at the parietal eminences. The cast of the skull of King Robert the Bruce also, copies of which may be found in many museums, shows that that valiant and sagacious monarch had, along with a retreating forehead, a large and capacious cranium.

From the comparison which has thus been instituted, I have no hesitation in saying that, although we may not be able to produce another skull possessing a combination of all those characters which are regarded as so distinctive of the Neanderthal skull, yet the examination of an extensive series of crania will show us that these characters are closely paralleled, not only in the crania of many savage races now existing, but even in those of modern European nations.

How cautious, therefore, ought we to be in generalizing either as to the pithecoid affinities or psychical endowments of the man to whom it appertained. It is as yet but an isolated specimen; of its history prior to the day of its discovery, we are altogether ignorant; its geological age even is quite uncertain. In coming to any conclusion, therefore, we have no facts to guide us, save those which are furnished by an examination of its structural characters. And whatever marks of degradation these may exhibit, yet they are closely paralleled in the crania of some of the men, and women too, now living and moving in our midst.

* 'Med. Times and Gazette,' April 12, 1862. Mr. Busk places the mean breadth of European crania at 5·65.

† The capacity of the largest cranium measured by Welcker was 114 cubic inches; that of the largest measured by Huschke, 109·75 cubic inches.



Hanhart imp.

Edwin M. Williams lith.

RECENT SKULLS.

ON THE APPLICATION OF THE PRINCIPLE OF "CONSERVATION OF FORCE" TO PHYSIOLOGY.

PART II. (conclusion): *The Relations of Light and Heat to the Vital Forces of Animals.*

By WILLIAM B. CARPENTER, M.D., F.R.S., F.L.S., F.G.S.

THOSE of our readers who accompanied us through the first part of our inquiry are aware that it was our object to show, that as Force is never *lost* in the Inorganic World, so Force is never *created* in the Organic; but that those various operations of Vegetable life which are sometimes vaguely attributed to the agency of an occult "Vital Principle," and are referred by more exact thinkers to certain Vital Forces inherent in the organism of the Plant, are really sustained by Solar Light and Heat. These, we have argued, supply to each germ the *whole power* by which it builds itself up, at the expense of the materials it draws from the Inorganic Universe, into the complete organism; while the mode in which that power is exerted (*generally* as Vital Force, *specially* as the determining cause of the form peculiar to each type) depends upon the 'germinal capacity' or directive agency inherent in each particular germ. The *first* stage in this constructive operation consists in the production of certain Organic Compounds of a purely Chemical nature—such as gum, starch, sugar, chlorophyll, oil, and albumen—at the expense of the oxygen, hydrogen, carbon, and nitrogen, derived from the Water, Carbonic Acid, and Ammonia of the atmosphere; whilst the *second* consists in the further elevation of a portion of these organic compounds to the rank of Organized Tissue possessing attributes distinctively Vital. Of the whole amount of Organic Compounds generated by the Plant, it is but a comparatively small part (*a*) that undergoes this *progressive* metamorphosis into living tissue. Another small proportion (*b*) undergoes a *retrograde* metamorphosis, by which the original binary components are reproduced; and in this descent of Organic Compounds to the lower plane, the power consumed in their elevation is given forth in the form of Heat and Organizing Force (as is specially seen in Germination), which help to raise the portion *a* to a higher level. But by far the larger part (*c*) of the Organic Compounds generated by Plants remains stored up in their fabric, without undergoing any further elevation; and it is at the expense of these, rather than of the actual tissues of Plants, that the life of Animals is sustained.

When, instead of yielding up any portion of its substance for the sustenance of Animals, the entire Vegetable organism undergoes retrograde metamorphosis, it not only gives back to the Inorganic World the binary compounds from which it derived its own constituents, but in the descent of the several components of its fabric to that simple condition—whether by ordinary combustion (as in the burning of Coal) or by slow decay—it gives out the equivalents of the Light and Heat by which they were elevated in the first instance.

In applying these views to the interpretation of the phenomena of

Animal life, we find ourselves, at the commencement of our inquiry, on a higher platform (so to speak) than that from which we had to ascend in watching the constructive processes of the Plant. For, whilst the Plant had first to prepare the *pabulum* for its developmental operations, the Animal has this already provided for it, not only at the earliest phase of its development, but during the whole period of its existence; and all its manifestations of Vital activity are dependent upon a constant and adequate supply of the same *pabulum*. The first of these manifestations is, as in the Plant, the building-up of the organism by the appropriation of material supplied from external sources under the directive agency of the germ. The ovum of the Animal, like the seed of the Plant, contains a store of appropriate nutriment previously elaborated by the parent; and this store suffices for the development of the embryo, up to the period at which it can obtain and digest alimentary materials for itself. That period occurs, in the different tribes of animals, at very dissimilar stages of the entire developmental process. In many of the lower classes, the embryo comes forth from the egg, and commences its independent existence, in a condition which, as compared with the adult form, would be as if a Human embryo were to be thrown upon the world to obtain its own subsistence only a few weeks after conception; and its whole subsequent growth and development takes place at the expense of the nutriment which it ingests for itself. We have examples of this in the class of Insects, many of which come forth from the egg in the state of extremely simple and minute worms, having scarcely any power of movement, but an extraordinary voracity. The eggs having been deposited in situations fitted to afford an ample supply of appropriate nutriment (those of the Flesh-fly, for example, being laid in carcases, and those of the Cabbage-Butterfly upon a cabbage-leaf), each larva on its emersion is as well provided with alimentary material as if it had been furnished with a large supplemental yolk of its own; and by availing itself of this, it speedily grows to many hundred or even many thousand times its original size, without making any considerable advance in development. But having thus laid up in its tissues a large additional store of material, it passes into a state which, so far as the external manifestations of life are concerned, is one of torpor, but which is really one of great developmental activity: for it is during the *pupa* state that those new parts are evolved, which are characteristic of the perfect Insect, and of which scarcely a trace was discoverable in the larva; so that the assumption of this state may be likened in many respects to a re-entrance of the larva into the ovum. On its termination, the Imago or perfect Insect comes forth complete in all its parts, and soon manifests the locomotive and sensorial powers by which it is specially distinguished, and of which the extraordinary predominance seems to justify our regarding Insects as the types of purely *Animal* life. There are some Insects whose Imago-life has but a very short duration, the performance of the generative act being apparently the only object of this state of their existence: and such for the most part take no food whatever after their final emersion, their vital activity being maintained, for the short period it endures, by the material assimilated during their larva state.* But those whose period of activity is prolonged, and upon whose energy there are extraordinary demands, are scarcely less voracious in their imago than in their larva-condition; the food they consume not being applied to the *increase* of their bodies, which grow very little after the assumption of the imago-state, but chiefly to their *maintenance;* no inconsiderable portion of it, however, being appropriated in the female to the production of ova, the entire mass of which deposited by a single individual is sometimes enormous. That the performance of the generative act involves not merely a consumption of material, but a special expenditure of force, appears from a fact to be presently stated, corresponding to that already noticed in regard to Plants.

Now if we look for the source of the various forms of Vital force, —which may be distinguished as constructive, sensori-motor, and generative,—that are manifested in the different stages of the life of an Insect, we find them to lie, on the one hand, in the Heat with which the organism is supplied from external sources, and, on the other, in the Food provided for it. The agency of Heat, as the moving power of the *constructive* operations, is even mere distinctly shown in the development of the larva within the egg, and in the development of the imago within its pupa-case, than it is in the germinating seed; the rate of each of these processes being strictly regulated by the temperature to which the organism is subjected. Thus ova which are ordinarily not hatched until the leaves suitable for the food of their larvæ have been put forth, may be made, by artificial heat, to produce a brood in the winter; whilst on the other hand, if they be kept at a low temperature, their hatching may be retarded almost indefinitely without the destruction of their vitality. The same is true of the pupa-state; and it is remarkable that during the latter part of that state, in which the developmental process goes on with extraordinary rapidity, there is in certain Insects a special provision for an elevation of the temperature of the embryo by a process resembling incubation. Whether, in addition to the heat imparted from without, there is any addition of force developed within (as in the germinating seed) by the return of a part of the organic constituents of the food to the condition of binary compounds, cannot at present be stated with confidence: the probability is, however, that such a retrograde metamorphosis does take place, adequate evidence of its occurrence during the incubation of the Bird's egg being afforded by the liberation of carbonic acid, which is there found to be an essential condition of the developmental process.—During the larva-state there is very little power of maintaining an independent temperature, so that the sustenance of Vital Activity is still mainly due to the heat supplied from without. But in the active state of the perfect Insect there is a *production of heat*

* It is not a little curious that in the tribe of *Rotifera*, or Wheel-animalcules, all the males yet discovered are entirely destitute of digestive apparatus, and are thus incapable of taking any food whatever; so that not only the whole of their development within the egg, but the whole of their active life after their emersion from it, is carried on at the expense of the store of yolk provided by the parent.

quite comparable to that of warm-blooded animals; and this is effected by the retrograde metamorphosis of certain organic constituents of the food, of which we find the expression in the exhalation of carbonic acid and water. Thus the food of Animals becomes an internal source of heat, which may render them independent of external temperature.—Further, a like retrograde metamorphosis of certain constituents of the food is the source of that *sensori-motor power* which is the peculiar characteristic of the Animal organism; for on the one hand the demand for food, on the other the amount of metamorphosis indicated by the quantity of carbonic acid exhaled, bear a very close relation to the quantity of that power which is put forth. This relation is peculiarly manifest in Insects, since their conditions of activity and repose present a greater contrast in their respective rates of metamorphosis, than do those of any other animals.—Of the exercise of *generative* force we have no similar measure; but that it is only a special modification of ordinary vital activity appears from this circumstance, that the life of those Insects which ordinarily die very soon after sexual congress and the deposition of the ova, may be considerably prolonged if the sexes be kept apart so that congress cannot take place. Moreover, it has been shown by recent inquiries into the Agamic reproduction of Insects and other animals, that the process of Generation differs far less from those Reproductive acts which must be referred to the category of the ordinary Nutritive processes, than had been previously supposed.

Thus, then, we find that in the Animal organism the demand for food has reference not merely to its use as a *material* for the construction of the fabric; food serves also as a generator of *force;* and this force may be of various kinds,—Heat and Motor-power being the principal but by no means the only modes under which it manifests itself. We shall now inquire what there is peculiar in the sources of the Vital Force which animates the organisms of the higher animals at different stages of Life.

That the developmental force which occasions the evolution of the germ in the higher Vertebrata is really supplied by the Heat to which the ovum is subjected, may be regarded as a fact established beyond all question. In Frogs and other Amphibia, which have no special means of imparting a high temperature to their eggs, the rate of development (which in the early stages can be readily determined with great exactness) is entirely governed by the degree of warmth to which the ovum is subjected. But in Serpents there is a peculiar provision for supplying heat; the female performing a kind of incubation upon her eggs, and generating in her own body a temperature much above that of the surrounding air.* In Birds, the developmental process can only be maintained by the steady application of external warmth, and this to a degree much higher than that

* In the Viper the eggs are usually retained within the oviduct until they are hatched. In the Python, which recently went through the process of incubation in the Zoological Gardens, the eggs were imbedded in the coils of the body; the temperature to which they were subjected (as ascertained by a thermometer placed in the midst of them) averaging 90° F., whilst that of the cage averaged 60° F.

which is needed in the case of cold-blooded animals; and we may notice two results of this application as very significant of the dynamical relation between Heat and Developmental Force,—first, that the period required for the evolution of the germ into the mature embryo is nearly constant, each species having a definite period of incubation,—and second, that the grade of development attained by the embryo before its emersion is relatively much higher than it is in cold-blooded Vertebrata generally; the only instances in which anything like the same stage is attained without a special incubation, being those in which (as in the Turtle and Crocodile) the eggs are hatched under the influence of a high external temperature. This higher development is attained at the expense of a much greater consumption of nutrient material; the store laid up in the "food yolk" and "albumen" of the Bird's egg being many times greater in proportion to the size of the animal which laid it, than that contained in the whole egg of a Frog or a Fish. There is evidence in that liberation of carbonic acid which has been ascertained to go on in the egg (as in the germinating seed) during the whole of the developmental process, that the return of a portion of the organic substances provided for the sustenance of the embryo, to the condition of simple binary compounds, is an essential condition of the process; and since it can scarcely be supposed that the object of this metamorphosis can be to furnish *heat* (an ample supply of that force being afforded by the body of the parent), it seems not unlikely that its purpose is to supply a force that concurs with the heat received from without in maintaining the process of organization.

The development of the embryo within the body, in the Mammalia, imparts to it a steady temperature equivalent to that of the parent itself; and in all save the *implacental* Orders of this class, that development is carried still further than in Birds, the new-born Mammal being yet more complete in all its parts, and its size bearing a larger proportion to that of its parent, than even in Birds. It is doubtless owing in great part to the constancy of the temperature to which the embryo is subjected, that its rate of development (as shown by the fixed term of utero-gestation) is so uniform. The supply of organizable material here afforded by the ovum itself is very small, and suffices only for the very earliest stage of the constructive process; but a special provision is very soon made for the nutrition of the embryo by materials directly supplied by the parent; and the imbibition of these takes the place, during the whole remainder of fœtal life, of the appropriation of the materials supplied in the bird's egg by the "food yolk" and "albumen." To what extent a retrograde metamorphosis of nutrient material takes place in the fœtal Mammal, we have no precise means of determining; since the products of that metamorphosis are probably for the most part imparted (through the placental circulation) to the blood of the mother, and got rid of through her excretory apparatus. But sufficient evidence of such a metamorphosis is afforded by the presence of urea in the amniotic fluid and of biliary matter in the intestines, to make it probable that it takes place not less actively (to say the least) in the fœtal Mammal than it does in the Chick *in ovo*. Indeed, it is impossible to study the growth of any of the higher organisms,—which not merely consists in the formation of new parts, but also involves a vast amount of interstitial change—without perceiving that in the remodelling which is incessantly going on, the parts first formed must be removed to make way for those which have to take their place. And such removal can scarcely be accomplished without a retrograde metamorphosis, which, as in the numerous cases already referred to, may be considered with great probability as setting free constructive force to be applied in the production of new tissue.

If, now, we pass on from the intra-uterine life of the Mammalian organism to that period of its existence which intervenes between birth and maturity, we see that a temporary provision is made in the acts of lactation and nursing for affording both food and warmth to the young creature, which is at first incapable of adequately providing itself with aliment, or of resisting external cold without fostering aid. And we notice that the offspring of Man remains longer dependent upon parental care than that of any other Mammal, in accordance with the higher grade of development to be ultimately attained. But when the period of infancy has passed, the child that is adequately supplied with food, and is protected by the clothing which makes up for the deficiency of other tegumentary covering, ought to be able to maintain its own heat, save in an extremely depressed temperature; and this it does by the metamorphosis of organic substances, partly derived from its own fabric, and partly supplied directly by the food, into binary compounds. During the whole period of growth and development, we find the producing power at its highest point; the circulation of blood being more rapid, and the amount of carbonic acid generated and thrown off being much greater in proportion to the bulk of the body, than at any subsequent period of life. We find, too, in the large amount of other excretions, the evidence of a rapid metamorphosis of tissue; and it can hardly be questioned (if our general doctrines be well founded) that the constructive force that operates in the completion of the fabric will be derived in part from the heat so largely generated by chemical change, and in part from the descent which a portion of the fabric itself is continually making from the higher plane of organized tissue to the lower plane of dead matter. This high measure of vital activity can only be sustained by an ample supply of food; which thus supplies both *material* for the construction of the organism, and the *force* by whose agency that construction is accomplished. How completely dependent the constructive process still is upon Heat, is shown by the phenomena of reparation in cold-blooded animals; since not only can the rate at which they take place be experimentally shown to bear a direct relation to the temperature to which these animals are subjected, but it has been ascertained that any extraordinary act of reparation (such as the reproduction of a limb in the Salamander) will only be performed under the influence of a temperature much higher than that required for the maintenance of the ordinary vital activity. After the maturity of the organism has been attained, there is no longer any call for a larger measure of constructive force than is required for the *maintenance* of its integrity; but there seems evidence that even then the required force has to be supplied by a retrograde metamorphosis of a portion of the constituents of the food, over and above that which serves to generate Animal Heat. For it has been experimentally found that, in the ordinary life of an adult Mammal, the quantity of food necessary to keep the body in its normal condition is nearly twice that which would be required to supply the "waste" of the organism, as measured by the total amount of *excreta* when food is withheld; and hence it seems almost certain that the descent of a portion of the organic constituents of this food to the lower level of simple binary compounds is a necessary condition of the elevation of another portion to the state of living organized tissue.

The conditions of Animal existence, moreover, involve a constant expenditure of *Motor* force through the instrumentality of the Nervo-muscular apparatus; and the exercise of the purely *Psychical* powers, through the instrumentality of the brain, constitutes a further expenditure of force, even when no bodily exertion is made as its result. We have now to consider the conditions under which these forces are developed, and the sources from which they are derived.

The doctrine at present commonly received among Physiologists upon these points may be stated as follows:—The functional activity of the nervous and muscular apparatuses involves, as its necessary condition, the disintegration of their tissues; the components of which, uniting with the oxygen of the blood, enter into new and simpler combinations, which are ultimately eliminated from the body by the excretory operations. In such a retrograde metamorphosis of tissue, we have two sources of the liberation of force;—first, its descent from the condition of living, to that of dead matter, involving a liberation of that force which was originally concerned in its organization;*—and second, the further descent of its complex organic components to the lower plane of simple binary compounds. If we trace back these forces to their proximate source, we find both of them in the *food* at the expense of which the Animal organism is constructed; for besides supplying the material of the tissues, a portion of that food (as already shown) becomes the source, in its retrograde metamorphosis, of the production of the Heat which supplies the constructive power, whilst another portion may afford, by a like descent, a yet more direct supply of organizing force. And thus we find in the action of Solar Light and Heat upon Plants—whereby they are enabled not

* It was by Liebig ('Animal Chemistry,' 1842,) that the doctrine was first distinctly promulgated which had been already more vaguely affirmed by various Physiologists, that every production of motion by an Animal involves a proportional disintegration of muscular substance. But he seems to have regarded the motor force produced as the expression only of the vital force by which the tissue was previously animated; and to have looked upon its disintegration by oxygenation as simply a consequence of its death. The doctrine of the "Correlation of Forces" being at that time undeveloped, he was not prepared to recognize a source of Motor power in the ulterior chemical changes which the substance of the muscle undergoes; but seems to have regarded them as only concerned in the production of Heat.

merely to extend themselves almost without limit, but also to accumulate in their substance a store of Organic Compounds for the consumption of animals—the ultimate source not only of the materials required by animals for their nutrition, but also of the forces of various kinds which these exert.

Recent investigations have rendered it doubtful, however, whether the doctrine that every exertion of the functional power of the nervo-muscular apparatus involves the disintegration of a certain equivalent amount of tissue, really expresses the whole truth. It has been maintained, on the basis of carefully conducted experiments, in the first place, that the amount of work done by an animal may be greater than can be accounted for by the ultimate metamorphosis of the azotized constituents of its food, their mechanical equivalent being estimated by the heat producible by the combustion of the carbon and oxygen which they contain ;* and secondly, that whilst there is not a constant relation (as affirmed by Liebig) between the amount of motor force produced and the amount of disintegration of muscular tissue represented by the appearance of urea in the urine, such a constant relation does exist between the development of motor force and the increase of carbonic acid in the expired air, as shows that between these two phenomena there is a most intimate relationship.† And the concurrence of these independent indications seems to justify the inference that *motor force* may be developed, like Heat, by the metamorphosis of constituents of food which are not converted into living tissue ;—an inference which so fully harmonizes with the doctrine of the direct convertibility of these two forces, now established as one of the surest results of Physical investigation, as to have in itself no inherent improbability. Of the conditions which determine the generation of motor force, on the one hand, from the disintegration of muscular tissue, on the other from the metamorphosis of the components of the food, nothing definite can at present be stated ; but we seem to have a typical example of the former in the parturient action of the Uterus, whose muscular substance, built up for this one effort, forthwith undergoes a rapid retrograde metamorphosis ; whilst it can scarcely be regarded as improbable that the constant activity of the Heart and of the Respiratory muscles, which gives them no opportunity of renovation by rest, is sustained not so much by the continual renewal of their substance (of which renewal there is no histological evidence whatever) as by a metamorphosis of matters external to themselves, supplying a force which is manifested through their instrumentality.

To sum up : The Life of Man, or of any of the higher Animals, essentially consists in the manifestation of Forces of various kinds, of which the organism is the instrument ; and these Forces are developed

* This view has been expressed to the author by two very high authorities, Prof. Helmholtz and Prof. William Thomson, independently of each other, as an almost necessary inference from the data furnished by the experiments of Dr. Joule.

† On these last points reference is especially made to the recent experiments of Dr. Edward Smith.

by the retrograde metamorphosis of the Organic Compounds generated by the instrumentality of the Plant, whereby they ultimately return to the simple binary forms (water, carbonic acid, and ammonia,) which serve as the essential food of vegetables. Of these Organic Compounds, one portion (*a*) is converted into the substance of the living body, by a constructive force which (in so far as it is not supplied by the direct agency of external heat) is developed by the retrograde metamorphosis of another portion (*b*) of the food. And whilst the ultimate descent of the first-named portion (*a*) to the simple condition from which it was originally drawn, becomes one source of the peculiarly Animal powers—the *psychical* and the *motor*—exerted by the organism, another source of these may be found in a like metamorphosis of a further portion (*c*) of the food which has never been converted into living tissue.

Thus, during the whole Life of the Animal, the organism is restoring to the world around both the *materials* and the *forces* which it draws from it; and after its death this restoration is completed, as in Plants, by the final decomposition of its substance. But there is this marked contrast between the two kingdoms of Organic nature in their material and dynamical relations to the Inorganic world,—that whilst the Vegetable is constantly engaged (so to speak) in raising its component materials from a lower plane to the higher, by means of the power which it draws from the solar rays, the Animal, whilst raising one portion of these to a still higher level by the descent of another portion to a lower, ultimately lets down the whole of what the Plant had raised; in so doing, however, giving back to the universe, in the form of Heat and Motion, the equivalent of the Light and Heat which the Plant had taken from it.

ON MILK, AND DAIRY ARRANGEMENTS.

By Dr. AUGUSTUS VOELCKER, Consulting Chemist to the Royal Agricultural Society of England.

AMONG the alimentary materials so bountifully supplied to man, there are few that may rank in importance by the side of the fluid whose constitution we are about to examine. Distinguished by a just combination of flesh-forming and fat-producing elements, with those salines which are best adapted for preserving the solution of the solid materials; remarkable for the facility with which the digestive system appropriates its nutriment; time-honoured as the support of helpless infancy; symbolical of mildness and sweetness, its very simplicity would seem a claim to its exemption alike from suspicion or inquiry; but, alas! for the materialism of the age, its value may be represented by so many pence, its mildness is perverted by adulteration, and the food of babes is too often suggestive of chalk and water, with a judicious thickening of brains and treacle. Milk, like everything else, being reducible to a question of money, we do not hesitate to adopt means to ensure, as far as possible, that we obtain our money's worth. Professing, as we do, a decided preference for the healthy and natural fluid, over any artificial representation of it, however superior in the estimation of the vendor, we call in the aid of science, to inform us what we ought to have, even if it gives us, at the same time, the miserable satisfaction of knowing that we have it not.

General Composition and Characters of Milk.—Milk is the secretion derived from the blood supplied to the mammary gland of the female animal, of the class mammalia. It is never produced in any quantity until after parturition; but during the latter part of utero-gestation it occurs in appreciable amounts, and instances are on record where it has been obtained from the gland of an animal previous to impregnation. The fluid secreted before parturition, and for some time afterwards, is called Colostrum, and contains a number of large corpuscules, filled with oil globules, distinguished as the "Colostrum Corpuscules."

Milk is white in colour, opaque, and has an agreeable sweetish taste; the odour is faint, but peculiar.

Its density is greater than that of water. Cows' milk, of good quality, has a specific gravity of about 1030; human milk 1020; Goats' and ewes' milk 1035 to 1042, and asses' milk 1019, compared with water at 1000.

The chemical reaction seems to be in a measure dependent upon the food, as might reasonably be expected, Carnivora giving milk possessing an acid reaction, and Herbivora an alkaline milk. Although apparently homogeneous, it may be separated into cream (which consists of oil globules, formed by thin envelopes of casein (curd), enclosing the fats of butter), curd, or casein, albumen, milk-sugar, and mineral matters, consisting chiefly of phosphate of lime and magnesia, as bone, earth, and salts of potassium and sodium, with some oxide of iron.

Cream—varies in composition, according to the circumstances under which it is produced. Four different samples analysed in my laboratory yielded the following results:—

<table>
<tr><th></th><th>I.</th><th>II.</th><th>III.</th><th>IV.</th></tr>
<tr><td>Water . . . .</td><td>74·46</td><td>64·80</td><td>56·50</td><td>61·67</td></tr>
<tr><td>Butter (pure fatty matters) .</td><td>18·18</td><td>25·40</td><td>31·57</td><td>33·43</td></tr>
<tr><td>*Casein . . . .</td><td>2·69</td><td rowspan="2">7·61</td><td rowspan="2">8·44</td><td>2·62</td></tr>
<tr><td>Milk-sugar . . . .</td><td>4·08</td><td>1·56</td></tr>
<tr><td>Mineral matters (ash) . . .</td><td>0 59</td><td>2·19</td><td>3·49</td><td>0·72</td></tr>
<tr><td></td><td>100·00</td><td>100·00</td><td>100·00</td><td>100·00</td></tr>
<tr><td>* Containing nitrogen .</td><td>·43</td><td>.. ..</td><td>.. ..</td><td>·42</td></tr>
</table>

Cream is lighter than milk, but slightly denser than pure water; consequently it sinks in distilled water. No. 1 was skimmed off after standing for 15 hours, and was found to have a specific gravity of 1·0194 at 62° Fahr. The specific gravity of two other samples of cream which stood 48 hours was 1·0127 at 62° Fahr., and 1·0129 at 62° Fahr. Rich cream, I find, has a lower specific gravity than thin cream mixed with a good deal of milk, such as the sample analysed under No. 1.

No. 2 may be taken as representing the composition of cream of average richness. It then contains about one-fourth its weight of pure butter.

These differences in the composition of cream fully explain the variable quantities of butter which are produced by a given bulk of cream.

On an average, one quart of good cream yields from 13 to 15 ounces of commercial butter. When very rich in fat, it will yield rather more. Thus Mr. Horsfall states that a quart of cream yielded 1 lb. of butter when the cows were at grass, and 22 to 24 ounces when they were housed and fed on rape-cake, bran, and other substances rich in oil.

The portions of cream which first rise, are thin, but rich in fat; this is due to the rupture of some of the oil globules during the milking, and subsequent agitation to which milk is exposed; the light fatty contents thus liberated naturally rise quickly to the top of the vessel in which the milk is set.

Good and poor milk differ mainly in the proportion of cream present; the appearance may not be much varied, except in extreme cases; consequently, for the determination of the quality, more reliable tests are required than the mere inspection of the fluid; and as a preparatory step to the consideration of the evidences afforded by the specific gravity under various conditions, a few observations may be offered upon the microscopic examination of milk in health and disease.*

Microscopic Examination of Milk in Health and Disease.—It must be some consolation to those who delight in miserable anticipations of dreadful mixtures in their daily food, to know that we possess a method of detecting, with absolute certainty, those combinations of "brains, chalk, and starch," a haunting suspicion of which makes the morning and evening meal distasteful.

Without positively asserting that such adulterations never exist, we may aver that we have never met with an instance. Foreign matters, of a nature unsavoury enough, and even unwholesome, we sometimes find, but they are the consequences of a diseased condition, or of an absence of common cleanliness. Such things as particles of dirt, from the milker's hands or the cow's udder, and cuticular scales from the same sources, are common enough. Globules of pus and blood discs are also found less frequently, but still oftener than we like to believe. It will not be thought that the microscope should be the companion to the breakfast-table: but in all cases where there is the least cause for suspicion, its revelations are infallible, and set at rest the doubt that is worse than certainty.

* The substance of the remarks on the microscopic appearance and the illustrations have been kindly contributed by my friend and former colleague, Professor G. T. Brown.

Good milk, under a tolerably high power, presents the appearance seen in our sketch (Fig. 1). Clustering masses of oil globules, the majority of uniform size, may be observed interspersed with a few larger, and a number of smaller ones, some being no more than fat granules of extreme minuteness. As occasional objects we may expect a few dirt particles, epithelial scales, or now and then two or three hairs. The appearance of the milk globules is so characteristic, that adventitious matters are in most cases discovered at once.

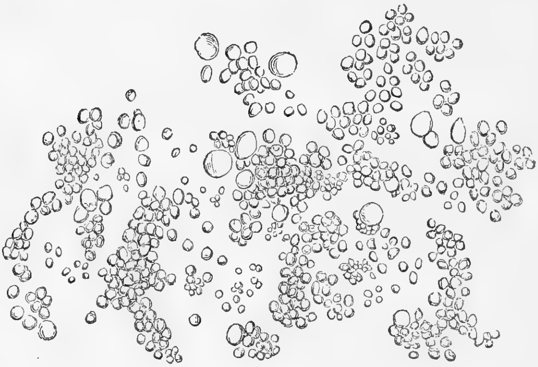


FIG. 1.—Healthy Milk.

From the number of oil globules collected together we may form some idea of the richness of the milk examined; but the microscope is not the best instrument for testing the proportion of oil globules in any given specimen, as in even very poor milk they will probably be collected in some parts of the field in sufficient numbers to lead to an erroneous judgment. In our illustration (Fig. 2) is represented a drop of milk so diluted with water as to be nearly transparent. The oil globules are seen in considerable numbers, although not in such masses as we find in the undiluted fluid. In portions of the specimen we should find the quantity apparently much increased by the natural flow of them to the most dependent part, and at *a* is an epithelial scale, of which occasionally small masses are discovered.

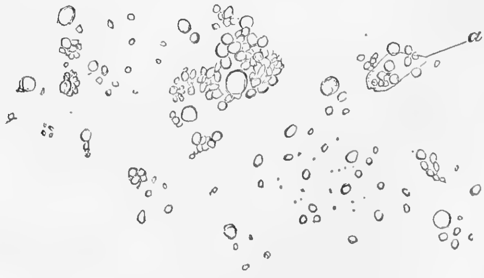


FIG. 2.—Healthy Milk largely diluted with Water.

In the event of pus, or blood, being mingled with the milk, it is evident that the gland is diseased; such elements could hardly be introduced by accident, and of a certainty would not be so intentionally. The appearance of the pus globule is very marked, as will be seen by reference to our drawing (Fig. 3, *a*). The faint outline, compared with the well-marked boundary of the oil globule, with the granular character and greater size, will be sufficiently distinctive; further evidence may be obtained by the addition of a small quantity of acetic acid, under whose action the nuclei of the pus cells soon become apparent, as at *b* and *c*, while the cell wall is gradually dissolved.

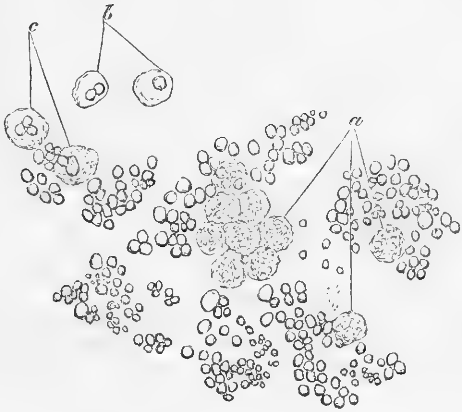


FIG. 3.—Milk with Pus.

The detection of blood discs is not so easy, for although they are essentially different from milk globules, their shape is materially altered by combination with the milk, which causes them to swell up and lose their peculiar dark centre. After the specimen, however, has been allowed to dry on the glass, the characteristic appearance is restored, and the blood discs are then very easily recognized.

The last Figure (4) represents blood discs in the milk, after being

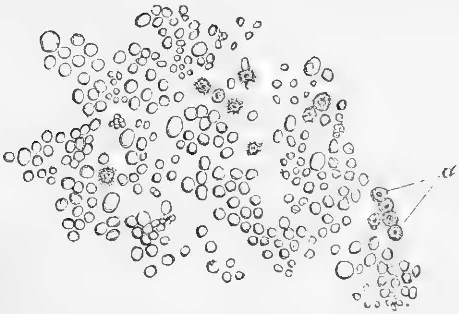


FIG. 4.—Milk with Blood.

allowed to remain for some hours on the glass. At *a* there are five of them, and others will be seen among the milk globules. Some of the blood discs have assumed a stellate form, but the dark centre is equally apparent in each.

On the subject of the Adulteration of Milk, and the means of Detection, nearly every writer mentions a number of materials said to be used in London, and other large towns, for the purpose of so improving the colour and consistency of milk that the water added to increase the bulk may not be so readily discovered. Whatever skill the milkman of the olden time may have possessed in this department of his trade, it seems to us that he of the present day is deficient in the modesty which afflicted his predecessor. We find now, at any rate, the "cerulean fluid" poured unblushingly into our jugs without an effort to disguise the sophistication, which, however harmless, not the less defrauds us of our due percentage of the coveted cream. So *honestly,* indeed, is the practice indulged in that we know more than one dairy-man of tender conscience who professes to supply milk of undoubted quality for the consumption of invalids and babies, while the robust are treated to an attenuation of the most unsubstantial kind.

The prevalent system of adulteration, we are convinced, consists in the admixture of water. Where the demand at certain seasons particularly exceeds the supply, the cow with the iron tail never fails to meet all demands however unreasonable, and doubtless deserves the reputation, so long ago acquired, of being the milkman's best friend.

Besides the intentional dilution of milk, there is a natural dilution dependent upon the derangement of the secretive function by the food, as is the case when such matters are supplied as distillery waste, bran mashes, grass from irrigated meadows, mangold tops, and acid slops, obtained by allowing barley meal, cabbage leaves, and other vegetable matters mixed with a great deal of water to pass through the lactic acid fermentation. The effect of such food is to induce the secretion of a large amount of water, and thus of necessity a poor quality of milk.

Whether the dilution of milk be intentional, or the result of certain influences acting upon the system, is to the consumer a matter of secondary importance, the great question being with him whether the milk is of good or bad quality.

My own experience leads me to conclude that a specimen of milk is rich when it contains 12 per cent. of solid matters, and about 3 per cent. of pure fat; anything above this is of extra rich quality.

Good average milk contains 10 to 11 per cent. of dry matter, and about 2½ per cent. of pure fat. It yields 9 to 10 per cent. of cream.

Poor milk, whether naturally or artificially diluted, contains 90 per cent. of water, and less than 2 per cent. of pure fat, and yields only 4 to 8 per cent. of cream.

For the purpose of determining the quality of milk, numerous instruments have been at various times invented; some of them are of doubtful utility, and nearly all require great tact on the part of the manipulator.

Hydrometers, or lactometers, specially adjusted for testing milk, may be obtained at a cheap rate at the philosophical instrument makers, and although not capable of furnishing evidence of so exact a nature as would be obtained by analysis, these are, nevertheless, very much more useful indicators than anyone would be inclined to believe, who did not know how far the specific gravity of milk is a test of its quality.

The lactometer was never intended to indicate the relative richness of good samples of milk, but to point out whether samples of a fair or doubtful appearance had been watered, or were of a naturally defective composition; and this purpose it satisfactorily fulfils.

Experiments were instituted in my laboratory for the purpose of ascertaining the influence of dilution upon the specific gravity, and the quantity of cream thrown up. Water being the standard at 1000; cream 1012 to 1019, and good milk 1·0320; the temperature being always 62° Fahr.

The following results were obtained :—

	Specific Gravity.	Percentage of Cream in bulk.
Pure milk at 62° Fahr.	1·0320	11½
„ and 10 per cent. of water at 62° Fahr.	1·0315	10
„ 20 „ „	1·0305	9
„ 30 „ „	1·0290	8
„ 40 „ „	1·0190	6
„ 50 „ „	1·0160	5

Experiments made upon milk after being skimmed gave the following :—

	Specific Gravity.
Skim milk	1·0350
„ with 10 per cent. water	1·0320
„ 20 „	1·0265
„ 30 „	1·0248
„ 40 „	1·0210
„ 50 „	1·0180

From these investigations it appears :—

1. That good new milk has a specific gravity of about 1·030.

2. That skim milk is a little more dense, being about 1·034.

3. That milk which has a specific gravity of 1·025 or less, is mixed with water, or naturally very poor.

4. That when milk is deprived of about 10 per cent. of cream, and the original volume is made up by 10 per cent. of water, the specific gravity of such skimmed and watered milk is about the same as that of good new milk; this circumstance, however, does not constitute any serious objection to the hydrometer, as milk skimmed to that extent cannot be mixed with water without becoming so blue and transparent, that no instrument would be required to detect the adulteration.

5. That when unskimmed milk is mixed with only 20 per cent. of

water, the admixture is indicated at once by the specific gravity of about 1·025.

6. That for these reasons the hydrometer or "lactometer" which gives the specific gravity of milk is well adapted for detecting the admixture of water, or to show an unusually poor quality of the unadulterated milk.

1. *Circumstances affecting the Quality and Quantity of the Milk.*—The period of the milking at which the sample is taken. During the process of milking, that which is first drawn off is thin and poor, and gives little cream: improving during the flow—the last drawn—the "strippings"—is the richest in quality, yielding better cream, and consequently more butter.

Experiments by Reiset and Pelligot have established the fact that considerably more solid matter and pure fat are contained in the milk last drawn from the udder.

This superior richness of the last-drawn milk has an important bearing upon the question of milking machines. The new American cow-milking machine fails to strip the udder, according to the united testimony of all who have tried it. Such a fundamental defect must militate against its general introduction into England, and has led to its disuse in the United States, as I am informed by the secretary of one of the most influential State Agricultural Societies.

It has, to my own knowledge, been tried by several excellent judges, who remain silent as to its merits, not liking to accept the unpleasant office of condemning and declining, as judicious men, to bestow undeserved praise.

2. *Distance from the time of Calving.*—The first milk, or colostrum, is thicker and yellower than ordinary milk, coagulates by heating, and contains an unusually large quantity of casein or curd.

In ten or twelve days from the time of calving, the milk assumes its ordinary condition, and the flow then becomes very plentiful; but after a month, or thereabouts, the yield gradually diminishes until the animal runs dry, usually in about ten months, unless when succulent and stimulating food is given to excite the continuance of the secretion for a longer time.

3. *Season of the Year and Food.*—In the spring and early part of summer milk is abundant, and of good flavour. As the season advances the supply is diminished, but becomes richer in butter. The same quantity of milk which in August scarcely yielded 3 per cent. of pure butter and 3 per cent. of curd, in November produced 4½ per cent. of butter and 3½ per cent. of curd.

A series of observations, made for the purpose of ascertaining the variations in the quality of the milk on the same farm throughout the year, convinced me that the supply of food was chiefly concerned, the richness or poverty of the diet being in all cases represented by the quality of the milk yielded.

In November and December the cows had meal-nut oil given to them, which is the refuse left after pressing ground kernels of the palm-nut. This substance, when of good quality, not too hardly pressed, is very nutritious and rich in fat,* and was found to exercise a decided influence upon the proportion of butter in the milk.

Brewers' grains are generally considered to possess a peculiarly stimulating effect upon the formation of the mammary gland. M. Struckman, of Wartburg in Germany, in 1855, published some feeding experiments, the results of which are of such practical importance as to justify an analysis of them here.

Four good and four bad cows were selected, and the diet included brewers' grains, mangolds, oat-straw, and rape-cake.

"Most milk was produced by $5\frac{1}{2}$ lbs. of rape-cake, 36 lbs. of mangolds, and 25 lbs. of oat-straw daily to each animal."

A reduction of 9-10ths lb. of rape-cake led to a decrease of 6·55 litres per cow daily; thus 1 lb. of rape-cake represents an average of $1\frac{1}{5}$ lb. of milk. A diminution of 6 lbs. of grains was followed by a reduction of 6·72 litres of milk; thus 1 lb. of grains appears to have produced $\frac{1}{4}$ lb. of milk.

When 18 lbs. of brewers' grains were replaced by $4\frac{1}{2}$ lbs. of rape-cake, the yield of milk was nearly the same; accordingly, 1 lb. of rape-cake was equal to 4 lbs. of grains, in its power of producing milk.

Rape-cake produced milk richer in butter; grains, however, produced butter of more delicate flavour.

During the experiments, the superior cows were found to be most influenced by the changes of food. In the inferior animals the yield was tolerably uniform, notwithstanding they were subjected to the same dietetic changes.

4. *Morning and Evening Milk.*—Popular opinion ascribes to the morning's milk a superiority in quality. Observations on this point do not sanction the conclusion, but rather tend to establish the conviction that the quality of the milk depends upon the food supplied some hours before the cows are milked.

If the food during the day has been plentiful and good, and the evening's food innutritious and scanty, the evening milk is of superior quality to that drawn on the following morning. Should the cows get a good supply of rich food in the evening, after having been stunted or fed on poor food during the day, the following morning's milk will be of a higher quality than that of the preceding evening.

Out of thirty-two samples of morning and evening milk, I found the morning's produce to be richer in four cases, and poorer in eight cases; whilst in four instances there was no perceptible difference.

* *Composition of Palm-nut Kernel-meal, by the Author.*

	No. 1.	No. 2.
Water	9·85	7·01
Fatty matters	24·14	22·45
† Albuminous compounds (flesh-forming matters)	16·43	12·90
Gum, sugar, and digestible fibre	26·60	26·61
Woody fibre (cellulose)	19·58	27·70
‡ Mineral matters (ash)	3·40	3·33
	100·00	100·00
† Containing nitrogen	2·63	2·02
‡ Containing sand	·63	·97

5. *Breed and Size of the Animal.*—It may be accepted as a fact, that animals which indicate a peculiar aptitude to fatten, are not likely to be distinguished as milkers; we do not assume that physiologically the two qualifications are incompatible, rather preferring the alternative conclusion that so much attention has been devoted to the selection of stock possessing the requisite qualities for feeding, that the milking capabilities have been passively ignored by the breeder. Pure Shorthorns, as a breed, are commonly objected to on the ground of their deficiency in this respect, although the circumstances of some families of pure bred animals being celebrated for the amount and quality of their milk, would seem to indicate that the stigma is too indiscriminately affixed to this breed.

The Yorkshire cow, essentially a Shorthorn, is the favourite of cowkeepers in London and other large towns, surpassing all others in the quantity of its yield, although the quality loses by comparison with that of smaller breeds.

If breeders would make it an object to cultivate both the feeding and milking qualities, there is nothing in previous experience opposed to a successful result.

Small breeds, or small individuals of large breeds, usually give a better quality of milk from the same food than large ones. The larger animals giving a better return in quantity, and furnishing more meat for the butcher, are, however, more profitable.

Where good quality is the main object, Alderneys perhaps will give most satisfaction, for they give richer cream than any other breed in common use in this country. The small Kerry cow, and the miniature Breton, produce extremely rich milk in quantity proportioned to their size.

For dairy purposes in cheese districts the Ayrshire are justly celebrated; indeed they seem to possess more completely than other breeds the power of converting the elements of food into cheese and butter; they do not, on the other hand, lay on fat and flesh well.

A cow of this breed bought by the Duke of Atholl from Mr. Wallace, Kirklandholm, produced from April 11, 1860, to April 11, 1861, 13,456 lbs., or about 1305 gallons of milk, which at 8*d.* per gallon would be worth 43*l.* 10*s.*

For general dairy purposes Shorthorns are probably the most useful. The dairy farmer will naturally select those that are more distinguished for milking qualities than for their tendency to fatten, at the same time not losing sight of the latter qualification, which will tell when the animals are no longer profitable for his dairy.

Health, Constitution, and Age might be enlarged upon as circumstances affecting the composition and quality of the milk: their influence, however, is too obvious to require more than a passing mention.

On Dairy Arrangements.

Aspect.—Our great aim should be to secure a position favourable for the preservation of dryness and uniformity of temperature all the year round. The best aspect is one facing the north, although this cannot be considered essential so long as the room can be kept dry, well ventilated, and protected by blinds from the direct rays of the sun.

Construction.—With the intent to secure the coolness which everyone knows to be desirable in summer, the dairy is sometimes built at a lower level than the ground. Underground dairies, however, are frequently damp; so that on a clay soil it is better to choose the lesser of two evils, and to build on a level with the ground.

In such localities, it is well to put a drain all round the building.

The walls should be thick, and if of stone, lined inside with brick. Presuming the dairy to be a separate structure, the roof should be covered with straw, which, being a bad conductor, best ensures a uniform temperature. Stonesfield slates or similar limestone flag-stones, or if these cannot be procured, common red tiles should be used in preference to black roofing slates, which, being good conductors, become very hot in summer. The floor should be of stone: large flagstones well set in cement appear to me preferable to ornamental or common small tiles; as it is an object to lessen the number of cracks in which water may lodge, rendering the floor constantly wet.

Ventilation.—A great defect in many of the dairies in England is the want of proper ventilation. This is a fertile source of dampness, so especially detrimental to the preservation of milk. One of the most effectual and inexpensive means of providing for a renewal of air, is to put up a perforated zinc grating 3 or 4 inches broad, which may be carried all along the tops of the windows. In addition, a whole window made to open and shut may be furnished with perforated galvanized sheet zinc.

Recourse may be had to more elaborate appliances; but the more complicated the apparatus the more difficult it will be to keep it in working order in the hands of the dairy attendants.

Temperature.—An equable heat being necessary in winter, it is best supplied by hot-water pipes; since, with a stove or open fire, it will be impossible to regulate the degree with sufficient nicety. Too much heat favours decomposition, and too little is unfavourable to the rapid separation of the cream.

A temperature not higher than 65° nor lower than 60° Fahr. is most conducive to the rising of the milk globules.

An accurate thermometer should be kept in the dairy; and on no account should the temperature be allowed to fall below 55°. Attention should be directed to the maintenance of a uniform degree of 60 as far as it is possible under all circumstances.

Benches of slate or marble are superior to wooden ones; but should economical considerations lead to the selection of wood, it should be painted, in order that any milk accidentally spilled may be readily removed. Milk easily penetrates a material so porous as wood, and is not readily removed. Cold water is quite ineffective, and even after the use of hot water, enough milk may remain in porous wood to generate an active ferment.

Milk-pails which are made of bright tin are decidedly better than wooden ones; unless great pains are bestowed in scouring the latter with boiling water, they taint the milk very quickly: tin pails can be always kept sweet and bright.

Pans should be constructed of glass, tinned iron or well-glazed earthenware; all porous materials are objectionable. Zinc pans are said to throw up more cream than those of other material; but zinc is readily oxidized, and like brass and tinned copper, however unobjectionable when kept clean, it may, in the hands of careless dairy-maids, furnish enough poison to injure the health of the consumer. Glass pans are easily kept clean, and well adapted for keeping milk and cream in a sweet condition. They are of course more liable to be broken, and therefore more expensive in the end than tin pans.

Deep pans are objectionable, as the quicker the cream can be made to rise, the sweeter it will be when used for churning, and the greater also will be the yield of butter according to Sennart's experiments.

Some allow the cream to become sour before they remove it; but, although in this state it appears more bulky, and of thicker consistency, it does not produce so much, nor so good a quality, of butter.

Shallow vessels are better than deep pans for another reason. If the milk is drawn from the cow into a shallow tinned-iron pan, the milk is soon reduced from 90° to 60°, and then, in a good dairy may be kept from thirty-six to forty-eight hours at a season when, in deeper vessels, it would soon turn sour.

Before the milk is put into pans it should be run through a straining-cloth. The accompanying sketch (Figs. 5 and 6) represents a vessel made of tinned-iron, with the straining-cloth tied round the spout.

Fig. 5.

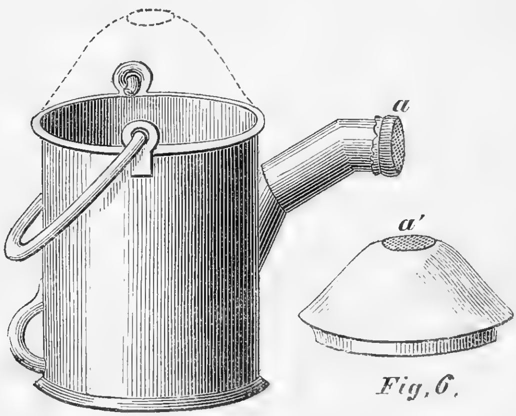


Fig. 6.

Cleanliness.—In no department of human industry is cleanliness more emphatically a virtue than in everything connected with the dairy. Too much attention cannot be bestowed upon the room itself, as well as upon the pails, pans, and other utensils.

The injudicious and wasteful employment of water must be deprecated. However convenient a good supply undoubtedly is, it must not be forgotten that a damp floor and moist atmosphere are to the last degree injurious. Whatever water is used should be scalding hot, and its evaporation assisted by a current of air. All the utensils should be washed without delay, instead of being set aside until wanted. The dairy-maid should not show her zeal for keeping the dairy clean by splashing water about. Above all, she should prevent men or women entering her domain with dirty shoes, or in any way bringing dirt into the dairy.

In wet weather the introduction of dirt may be unavoidable, but it may be reduced to a minimum by having a good scraper and rough door-mat at the entrance, as well as a pair of wooden shoes, which may be easily slipped on and off, for each man who brings in the milk.

Anyone who doubts the efficacy of these simple means should visit North Brabant, which is justly celebrated for its excellent butter. Dairies, which are models for cleanliness, can be seen, not here and there, but almost universally throughout the district. It is, we are quite aware, difficult to ensure the proper conduct of a dairy with all the requisite exactitude, but the trouble is well bestowed, and cleanliness, like any other virtue, is its own reward.

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PROCEEDINGS OF METROPOLITAN SOCIETIES.*

THE ROYAL ASTRONOMICAL SOCIETY.

The contributions to the transactions of this Society have been, during the period which we are about to chronicle—namely, the months of November, December, and January—of an extremely interesting character, and the subject to which the largest amount of new information has been added is the physical character of the Sun.

Let us state by way of preface, however, that at the first meeting of the session, November 13, 1863, the business of the meeting commenced with an announcement from the chairman, Dr. Lee, V.P. (who presided in the absence of the President, the Astronomer Royal), to the effect that an Anglo-French astronomical treaty had been made, the contracting parties being M. Le Verrier, the director of the Paris Observatory, on the one side, and our own Astronomer Royal on the other; the object of which is so to divide the large amount of work that is usually exacted from national observatories between the two establishments so that, whilst nothing important is omitted, the astronomical observer shall have some relief at those seasons when the requirements of science press peculiarly heavy upon him.

The observations of the Moon, as our readers are aware, have ever been followed at the Greenwich Observatory with unfailing assiduity. Whilst that body passes the meridian in the evening, the addition of the planetary observations only adds to the labour of the Observatory in proportion to the number of observations; but when the moon is a morning observation, the evening observations of the planets add a very oppressive labour. In order to diminish this oppression on the staff, an arrangement of the following kind has been made between the directors of the two Observatories:—The Paris Observatory undertakes the planetary observations from full moon to new moon, the Greenwich Observatory those from new moon to full moon. The small planets are, with some few exceptions, observed only between the hours 10 and 13, solar time. It is to be hoped that this example will be followed, not only by public Observatories, but by the many private establishments which are in the habit of doing good work. A very great amount of labour and time is no doubt wasted through the want of *combined* effort.

We must, however, for the present pass over the papers read at the November meeting, and refer to two by the Rev. W. R. Dawes, at those of December and January, on "*The Telescopic Appearance of the Exterior Envelope of the Sun and of its Spots.*"

Solar physics always command a great deal of interest, and the name

* Our limited space, and still incomplete organization, necessitate the postponement of articles on the Proceedings of two or three Metropolitan Scientific Societies.

of Mr. Dawes is so well known in that particular field of research that any paper from him on the subject is heard with respect. The author commenced by pointing out the danger there was that observers, furnished with the more powerful telescopes now generally in use for solar inspection, would consider as *new discoveries* what was really only the revelation of superior telescopic power; but which remained unrevealed in the diminished apertures formerly in use. This would be more likely the case where *new names* have been applied by a recent observer to phenomena long familiar to others, though previously unnamed. Mr. Dawes has therefore considered it advisable to describe very minutely appearances which were observed long ago, that the new observer should know precisely what has already been seen in good instruments. Such an explanation was undoubtedly needed, as it is calculated to save much anxiety to the unpractised observer.

With regard to the 'mottled' appearance of the solar surface, which is familiar to every observer, but in the description of which so many, and, to our minds, fanciful images have been used, Mr. Dawes makes the following remarks:—"Examined with a large aperture, such as 6 or 8 inches, it becomes evident that the surface is principally made up of luminous masses, imperfectly separated from each other by rows of minute dark dots,—the intervals between these dots being extremely small, and occupied by a substance decidedly less luminous than the general surface." . . . "This gives the impression of a division between the luminous masses, especially with a comparatively low power, which, however, when best seen with high powers, is found to be never complete." . . . "The masses thus incompletely separated are of almost every variety of irregular form;—the rarest of all, perhaps, being that which is conveyed to my mind by Mr. Nasmyth's appellation of '*willow-leaves*;' viz. *long, narrow*, and *pointed*." * . . . "Indeed the only situation in which I have usually noticed them to assume anything like that shape, is in the immediate vicinity of considerable spots, on their *penumbræ*, and frequently projecting beyond it irregularly for a small distance on to the *umbra*."

Mr. Dawes negatives the opinion, held by Sir John Herschel, amongst others, and mentioned in his *Outlines*, that the minute dark dots are ever in a state of change. He believes, from his own experience, that when observers have fancied they detected change, it was due to the influence of atmospheric action. There is, however, an exception to this state of quietude, "in the immediate vicinity of spots which are

* At the next meeting of the Society, a letter from Mr. Nasmyth to Mr. Hodgson was read, in which the former gentleman made the following remarks concerning the "willow leaves":—

"The filaments in question are seen, and appear well defined, at the edges of the luminous surface where it overhangs the 'penumbra,' as also in the details of the penumbra itself, and most especially are they seen clearly defined in the details of 'the bridges,' as I term those bright streaks which are so frequently seen stretching across from side to side over the dark spot. So far as I have yet had an opportunity of estimating their actual magnitude, their average length appears to be about 1,000 miles, the width about 100."

"There appears no definite or symmetrical arrangement in the manner in which they are scattered over the surface of the sun; they appear to lie across each other in all possible variety of directions."

either rapidly enlarging or closing. It is under these circumstances especially that the luminous masses are found to become more elongated. This is also more remarkably the case when they are *preparing for a rush across a chasm,* and thus forming those luminous bridges which so often intersect considerable spots."

After detailing some more facts connected with the formation of these luminous bridges, the author draws attention to the distinction between the true or blacker *nucleus,* and the *umbra.* In almost all large spots the former is found to occupy some portion of the latter; and the author thinks that the establishment of the fact of the existence or absence of such black nucleus is "sufficient to determine, or at least to throw much light upon the *origin* of the spot; and that the origin of those in which the nucleus exists is widely different from the origin of those from which it is absent."

The author's second paper on the same subject, delivered in January, was to some extent a recapitulation of the first, after which he proceeded to communicate further details concerning the solar spots.

These he divides into two classes, which he names the *profound* and the *superficial;* and thus describes the characteristics of each.

"The *profound.*—In this class I should include those which give evidence of involving all the visible envelopes, the disturbance being observable through them all, and down to what appears to be the body of the sun itself."

"The *superficial spots.*—These appear, from the general tenour of my observations, to be almost always produced by convulsions of some kind in the photosphere itself, or at a small depth below it. But, from the extraordinary variety of the effects, I confess that I am not prepared to add anything to the suggestions already advanced as to the character of those convulsions, or the means by which they may be produced."

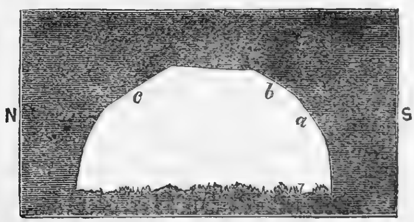
With regard to the probable formation of the *profound* spots, Mr. Dawes arrives at the following conclusions:—

"An immense volume of some non-inflammable gas, discharged with prodigious force from the body of the sun by volcanic or some similar agency, bursts through the *cloudy stratum,* rolling back on all sides the displaced portion of that stratum, and producing that heaped-up appearance at its inner and lighter edge. The *black hole* produced in the stratum by this volcanic eruption forms the *nucleus* of the spot." "Having passed through the cloudy stratum, the evolved gas comes within the influence of the heating power of the self-luminous penumbral stratum; and being greatly expanded thereby, its increased volume removes a far larger area of this second stratum than of the first; thus laying bare a considerable portion of the upper surface of the cloudy stratum, and producing the *umbra* of the spot. Here, too, the rolling back of the removed portion causes a heaped-up and brighter appearance at the inner edge of the penumbra. Being still further heated, and expanded by approaching the photosphere, a similar effect is produced upon this upper stratum, but to a far greater extent; and a much larger portion of the photosphere is thrown off on all sides, which being, as before, rolled back upon the rest, gives the appearance of a heaping-up of the luminous masses at the extreme edge of the spot." . . "The *rotary* motion of a *profound* spot may be produced by the exploded gas having acquired a whirlwind sort of action, and thus carrying round the parts of the different strata affected by it in the same direction."

At the close of the paper Mr. Dawes gives as an addendum some extracts from an elaborate paper by Sir William Herschel, printed in volume XCI. of the 'Philosophical Transactions,' in which the observations of many years are discussed; and which seem in many particulars to bear out the observations of Mr. Dawes.

Next to the sun, the moon is perhaps the most interesting body to the amateur observer, and we generally have a paper of some kind about her at one or more meetings during the session. Mr. Birt did not fail with his favourite topic at the first meeting, and gave the Fellows a paper on the *Extension of Lunar Nomenclature.* Many craters still remain on our maps unnamed, whilst there are several that have been altogether omitted, and that too on our best lunar maps. These latter Mr. Birt has laid down; whilst to those wanting names he has, in conjunction with Dr. Lee, of Hartwell, given designations. A list is appended of the spots so named, with their numbers (in accordance with those adopted by the Rev. T. W. Webb), together with the selenographical longitudes and latitudes of each.

The moon also furnished the subject of a paper by the Rev. H. C. Key, entitled "*On Certain Depressions on the Moon's Western Limb;*" and as the paper contains some observations of a novel character, we shall treat somewhat more fully of the subject. The author does not mean the general depressions on the moon's surface, but as he himself expresses it, "of depressions of large area—not of comparatively small gullies, lying between elevated ranges, which are constantly to be seen projected on the limb, but of vast tracts, the general level of which lies very considerably beneath the mean level of the moon's surface." Mr. Key took great pains to satisfy himself that the instrument was in proper adjustment, and that the phenomenon he observed was not due to any defect in the telescope. Perhaps the best way of showing our readers the extraordinary nature of these depressions, will be to present them with a copy of the drawing illustrating the paper in question.



The circumstances of the discovery are thus related:—"Having mounted my new 12-inch glass speculum, I had for some time past been making experiments with it, in the unsilvered state, upon celestial objects, with the view of ascertaining how far a diminution of light and consequently of the evils of irradiation, combined with a large aperture, might be of advantage in particular cases. For this purpose, on the 20th of September, at about 6 p.m , before the sun had set, I turned the telescope upon the moon, then a few hours past her first quarter. I had no sooner focussed the telescope (power 120) than I was astounded at observing that the limb of the moon was entirely *out of shape*; that it was, in fact, irregularly polygonal, as if several large segments had been cut off the spherical limb—not the terminator."

Upon observing these remarkable appearances the author wrote to his friend, Mr. Webb, who, on examination. at once detected them; and proved their existence beyond a doubt by the use of the wire of the micrometer. Subsequently, September 25th, when Mr. Key again examined the limb he was only able to trace a very faint appearance of a depression. From this circumstance the author is led to believe that the maximum visibility of these depressions only lasts for a short period; and that the effect of irradiation would render their detection in ordinary instruments extremely difficult.

Now that this extraordinary phenomenon has been once discovered, it is to be hoped that observers will direct their attention to so interesting a subject, and will provide themselves with instruments calculated to exhibit more perfectly the true form of the limb. For this object Mr. Key strongly urges the adoption of the plain, in addition to the silvered speculum. We should state that the drawing was made from memory the following day, and although it but represents roughly the positions of the depressions, he does not consider them exaggerated. The deepest depression below the surface of the moon he estimates at about 25 miles.

A paper, "*On the Origin of the apparent Luminous Band which, in partial Eclipses of the Sun, has been seen to surround the Visible Portion of the Moon's Limb*," was communicated to the Society by G. B. Airy, Astronomer Royal. The object of this paper was "to show, by optical investigation, that no refraction can cause a change in the apparent brightness of the surface viewed." As the paper was necessarily of a purely mathematical character, we shall content ourselves with merely giving our readers its general results. Having arrived, from this treatment of the subject, at the conclusion that "refraction by a lunar atmosphere cannot explain the more luminous band which appears to surround the moon's limb where it crosses the sun's disc," the author goes on to state his opinions on its real origin in very positive terms: "I have no difficulty in explaining to myself the origin of the luminous band in question. It is strictly an ocular nervous phenomenon; not properly subjective, but sensational—a mere effect of contrast. I have seen it so frequently under circumstances very different from these, that I cannot have the smallest doubt on the matter."

In this paper the author entertains views antagonistic to those previously expressed by Professor Challis, in a paper contained in the 'Monthly Notice,' June 12, 1863, and at the meeting in January last Professor Challis communicated a paper "*On the Calculation of an*

Optical Effect of Atmospheric Refraction," which is, in fact, a reply to Mr. Airy's. The latter observer, in his argument, assumed the effect of an atmosphere to be analogous to that of a convex lens, and on this assumption investigated the case mathematically. But Professor Challis contends that the courses of rays passing through a medium of variable density, like the atmosphere, cannot be similar to those passing through a convex lens; and that, therefore, in investigating the point at issue, respect must be had to the variation of the refractive index, in passing from one point of the medium to another.

The Astronomer Royal has also contributed a few remarks on the amount of light given by the moon at the greatest stage of the 1863 June 1 eclipse. As this eclipse, from the cloudless state of the sky, was very generally an object of observation, we give the Astronomer Royal's remarks in full:—

"The state of sky and of atmosphere was exceedingly favourable for observation of the lunar eclipse of last night. At the time of greatest obscuration, I carefully compared the light of the moon with that of several neighbouring stars. This I could do with considerable accuracy, by observing the objects with the eye unarmed, as my near-sightedness converts every object into a broad luminous disc, and there is no essential difference in the appearance of the moon and of a star, excepting in the quantity of light. In this manner I found that the light of the moon considerably exceeded that of *Antares*, sensibly exceeded that of *Spica*, and somewhat exceeded that of α *Ophiuchi*, but was a very little less than that of α *Aquilæ*.

"It will be remarked that the moon's centre was 22′ distant from the centre of the shadow at the time of conjunction in R.A., so that the moon was not very deeply plunged in the umbra. Had the eclipse been central, the light would have been much less."

We have to notice briefly the following papers, communicated at the meetings of November, December, and January; to which our limited space prevents our making a more lengthened reference:—

F. Abbott, Esq., communicated some observations on the variable star η *Argus*. This same η Argus has been an object of scrutiny by other astronomers, and to whom it has caused some perplexity, and, amongst others, by Sir John Herschel, when at the Cape, with an 18-inch reflector. On that occasion, Sir John wrote in the following terms:—"No part of this Nebula shows any sign of resolution into stars." The form of the Nebula amongst which the star was situated is, as our readers are aware, figured in the 'Outlines of Astronomy' in the shape of a dumb-bell, the star appearing of the first magnitude, and situated in its most dense part. It now seems that, although the star is in the dark space, out of the Nebula, which has altered in form, it only appears as a body of the sixth magnitude. These changes, both in Nebula and star, have taken place between 1838, the date of Sir John's observations, and last year, when Mr. Abbott examined it. The author suggests that the variability of the star might be occasioned by the interference of the nebulosity surrounding it.

A letter was read from Mr. Higgens, addressed to Admiral Smyth, in which the writer forwarded some notes on the two component stars of 95 *Herculis.* The instruments used were a $3\frac{1}{4}$-inch acromatic with 80, and a 4-inch with 115: both by Cooke of York. Mr. Higgens observed these stars in April, May, and August last, and witnessed some remarkable changes in their apparent colour. From the fact of both stars appearing to change their colour simultaneously, the Astronomer Royal thought it implied some possible change in the telescope.

Capt. Noble, and C. L. Prince, Esq., communicated their observations of Venus at the Inferior Conjunction; the latter gentleman also his observations of the occultation of *κ Cancri* by the Moon, on the 26th April 1863.

Sir A. Lang sent some observations made in the Island of St. Croix, at the rising of the sun, with a view to determine the Refraction: also, some notes on remarkable sun-spots in 1862-63.

The elements of the new Minor Planet (79), 10th magnitude, discovered by Mr. Watson, Director of the Ann Arbour Observatory, were also given.

An extract from a letter to Mr. De La Rue, from Dr. Winnecke, was read, which went to show the probability of the variableness of light of some of the feebler stars about the neighbourhood of the Trapezium in the great Nebula of Orion.

The translation of a paper by P. A. Hansen, "*Calculation of the Sun's Parallax from the Lunar Theory,*" was communicated by Mr. Airy. The result gave 8."9159 as the Parallax.

Results of the meridional observations of small Planets, *Angelina* (64) and *Cybele* (65); also occultation of stars by the Moon; and Phenomena of Jupiter's satellites; made at the Royal Observatory, were given by the Astronomer Royal.

New Elements of *Leto* (68) were communicated by Dr. Luther, of Berlin.

The Elements and Ephemeris of Comet IV, and notes of observations of Comet IV and V, 1863, by H. Romberg, were communicated by J. G. Barclay, Esq., at whose observatory they were made.

Mr. E. J. Stone presented a paper, "*On the Motion of the Solar System in Space,*" forming a supplement to one on the same subject read by the Astronomer Royal, at the meeting, March 11, 1859.

"*On the Eclipses recorded in the Ancient Chinese Historical Work called Chun Tsew,*" is the title of a paper by the Assistant Secretary, J. Williams, Esq. "The Chun Tsew," writes Mr. Williams, "is said to be the only work really written by Kung Foo Tze, or, as we call him, Confucius; the other treatises attributed to him having been compiled by his disciples, either during his lifetime, or, as in the last of them, some years after his death. It treats of the history of Le Kwo, or Confederated Nations, into which China was divided during the during the Chow Dynasty, *viz.* between 1122 and 255 B. C."

"The period of this history is from 722 to 479 B. C., being an interval of about 242 years, during the latter part of which Confucius flourished." . . . "The account of each eclipse is but little more than a brief mention of its occurrence at a certain time."

Mr. Williams presents us with a specimen as follows:—"In the fifty-eighth year of the thirty-second cycle, in the fifty-first year of the Emperor King Wang, of the Chow Dynasty, the third year of Yin Kung, Prince of Loo, in the spring, the second moon, on the day called then Tsze, there was an eclipse of the sun." This date answers to 720 B.C.

A complete list of all such eclipses, with the year B.C., and month and day answering to the Chinese dates, is added. The days have been computed by Ideler's method, but Mr. Williams warns his readers that they must only be considered as approximate.

Mr. E. J. Stone presented a Memoir, entitled "*Proper Motions of the Stars of the Greenwich Seven-year Catalogue of* 2,022 *Stars for* 1860, *not included in the Greenwich Twelve and Six-year Catalogues, deduced by Comparison with the Results of Bradley's Observations, as given in Bessel's Fundamenta Astronomiæ.*" This Memoir forms a continuation to those by Mr. Main.*

J. R. Hind, Esq., communicated a note, "*On the Variable Nebula in Taurus;*" in which he records that, on the 12th of December, no trace of the Nebula could be seen either by himself or Assistant, although the atmosphere was in a most favourable condition for Astronomical observation.

M. G. de Pontécoulant communicated a paper "*Sur le Coefficient de l'Equation Parallactique déduit de la Théorie,*" suggested by some notes by Mr. Stone and M. Hansen in a former volume of the "Notices." The paper did not present any point of general practical interest.

At the November meeting, M. Léon Foucault, M. Knowalski, M. Winnecke, and Prof. G. P. Bond, were duly elected Associates of the Society. With one or two unimportant omissions, we think we have here communicated to our readers the pith of the proceedings of the Royal Astronomical Society.

THE CHEMICAL SOCIETY.

Up to the present time, the proceedings of the Chemical Society, during this quarter, have been destitute of any especial interest. The law of the absorption of mixed gases in water has become an important subject of inquiry since Bunsen has proposed absorption as a method of analysis. A promising chemist, Mr. W. M. Watts, has experimented with mixtures of ammonia and hydrogen, and of sulphurous and carbonic acid, principally with the view of testing the truth of Dalton's conclusion, that each gas is retained in water by the pressure of gas of its own kind; no other gas with which it may be mixed having any permanent influence in this respect. The results of Mr. Watts' experiments have led him to the conclusion that the proportion of mixed gases absorbed is not in accordance with Dalton's simple law.

* See vols. xix. and xxviii. of the Transactions of the Society.

A contribution to physiological chemistry, on the vexed question of the colouring matter of urine, was communicated by Dr. Thudicum, who believes that he has isolated both the pigmentary and odorous principles of this secretion. The former body he designates *urochrome*, the latter, *otto of urine.* In the absence of any analysis of these bodies, and without an exact knowledge of the manner in which they are to be obtained, the question, "What is the colouring matter of the renal secretion?" may be still considered open, unless, with Dr. Harley, we believe it to have been settled by Scherer. This distinguished chemist and physiologist succeeded in isolating a red matter, to which he gave the name of *urohœmatin*, since it presented a close analogy to the colouring matter of the blood, by containing an appreciable amount of iron. Scherer considered the body to result from this disorganization of the blood corpuscles, the waste of which was eliminated from the system in this form. This is an ingenious theory, and the question deserves further examination. Dr. Thudicum finds the merest trace of iron in his urochrome; but we must wait for a more complete account of the author's researches.

The formation of new bodies, by the abstraction from other bodies of certain elements or molecules of elements, and substituting for these certain other elements or groups of elements, the resulting compounds having well-defined and characteristic individualities; and further than this, the production of natural from artificial substances (like the formation of tartaric acid from dibromosuccinic, by Mr. Perkin), by successive substitutions, may rank among the greatest triumphs of human ingenuity. Perhaps the most prolific parent of artificial bases has been Dr. Hoffmann, whose skill in effecting the transformations is only equalled by the lucidity with which he explains them.

Apropos to a paper on Acetanilide, by Mr. C. G. Williams, the Chemical Society recently heard from Dr. Hoffmann a short account of a series of new creations, obtained by the action of chloroform on aniline, and of pentachloride of phosphorus on a mixture of aniline and acetanilide—the first of an infinite series of bodies which may be produced by similar reactions on similarly-constituted substances. The names of these new bodies, diphenyl-formyl-diamine, and diphenyl-acyl-diamine, show them to be of interest only to advanced chemists. New instances of conversion were brought forward at the same meeting, malic acid having been converted into malonic, and propionic acid into succinic, by Kolbe and by Muller.

The question, "What is the best form in which nitrogen and phosphorus can be applied as manure to plants?" has engaged the attention of many minds; but perhaps the most original experiments made on the subject, have been those of M. Ville, recently described to the Chemical Society by Dr. Hoffmann. M. Ville has, however, come to the conclusion that none of the compounds of phosphorus and nitrogen answer better than those in common use—phosphoric acid and ammonia. It will be of interest to farmers who study chemistry, to learn that ethylamine and methylamine seemed to produce no better results than their prototype ammonia.

At the meeting on March 3rd, a very interesting paper on the non-metallic impurities in Refined Copper, by Mr. Abel, was read. The metallic impurities in copper had been fully treated of in previous contributions by the same author. The impurities mentioned in the present paper are Oxygen, Sulphur, and Selenium. Oxygen exists in copper in the form of a suboxide of the metal, which is soluble in the fused copper. The exact quantitative determination of the oxygen was a matter of extreme difficulty, but the process now given by Mr. Abel makes it a comparatively simple matter. Pure copper decomposes nitrate of silver, the latter metal being deposited, and a corresponding amount of nitrate of copper being formed. When, however, suboxide of copper is present a subsidiary action takes place, and insoluble basic nitrate of copper is formed. The author, therefore, converts a known weight of the copper into nitrate by digesting with a neutral solution of nitrate of silver, collects and washes the silver and basic nitrate of copper on a filter, and subsequently digests with a known volume of weak standard sulphuric acid (one part to a hundred of water) to dissolve the basic nitrate of copper formed. The proportion of sulphuric acid neutralized in this operation is ascertained by means of a standard solution of carbonate of soda, and the amount of oxygen or suboxide of copper is calculated therefrom. In the course of these experiments it was noticed that the physical structure of the metal afforded some indication of the amount of oxygen. Ingots which exhibited depressions on the upper surface were invariably found to contain more oxygen than those which were flat. The amount of oxygen present in Kapunda copper, we may add, was found to vary from ·12 to ·33 per cent. In Swansea copper in different stages of manufacture, Mr. Abel found the amount of oxygen to vary from 0·42 per cent. in "Dry" Copper, to 0·03 per cent. in "Over poled." While looking for carbon the author found selenium in copper, but in an excessively minute quantity, 0·003 per cent. It is worth mentioning that Mr. Abel could find no evidence of a combination of copper and carbon. Sulphur was found in very small quantity, but neither phosphorus nor nitrogen could be detected. Silicon might be present in a portion of inclosed slag, but not in combination with the metal.

At the same meeting a communication on the Synthesis of Leucic acid, was made by Dr. Frankland. Leucic acid has been obtained by the author synthetically, by the substitution of one atom of oxygen in oxalic acid, by two atoms of ethyl. This was effected by acting on oxalic ether with zinc ethyl.

THE GEOLOGICAL SOCIETY.

Since the Anniversary of last year some very important and interesting papers have been contributed to the Proceedings of this Society, most of them suggesting new interpretations of known facts, but some also referring to phenomena hitherto unknown or, at any rate, never before explained. The field over which the researches embodied in these various memoirs extends is a wide one, including as it does the following subjects:—(1) Breaks in the Succession of the British Palæozoic Strata; (2) Fossil Estheriæ; (3) Relation of the Permian Fauna and Flora to those of the Carboniferous Period; (4) Origin of the Parallel Roads of Glen Roy; (5) River-action; (6) Geology of the West Indian Islands; (7) The Abbeville Jaw and the associated Flint Implements; (8) Geology of the Eastern Archipelago, besides a number of other questions, of either more special or merely local interest.

1. The subject of the Anniversary Address of the President of the Society, Professor Ramsay, reminds every geologist how imperfect is our knowledge of the rock-formations which constitute the crust of the earth, the theme being "Breaks in the Succession of the British Palæozoic Strata." It is, moreover, one upon which no author has before written systematically, although many have described particular breaks incidentally when treating of other subjects.

"Breaks in Succession" are defined by Professor Ramsay to be "those physical interruptions in stratification marked by the unconformity of an upper formation to one immediately underlying it, or, when such visible unconformity is wanting, by a sudden change in the fossils characteristic of the underlying and overlying formations;" but he immediately afterwards introduces a necessary limitation, stating that he only applies his argument "to those cases in which the upper formation is next in time to that which underlies it, according to our present knowledge of the order of succession." Now these breaks are as good evidences of the lapse of time as a series of strata would be.

Before the publication of this address few geologists would have admitted the existence of as many as ten physical breaks, as above defined, in the primary rocks of Britain, yet Professor Ramsay, in a series of very lucid arguments, shows the existence of at least that number of gaps in our palæozoic series, and also that they are accompanied (except in one case, where the rocks are almost barren) by "great and remarkable changes in the number and nature of the fossils." He also discusses the questions arising out of a consideration of this coincidence, especially the old notion that entire faunas had been suddenly destroyed, and the theory of Professor E. Forbes (lately revived in another shape by Professor Huxley) respecting the contemporaneity of strata; together with Mr. Darwin's hypothesis of the origin of species, of which he appears to be a warm advocate.

The conclusion to which he arrives respecting the lapse of time represented by these breaks is rather startling; and although no geologist is better qualified than Professor Ramsay to judge of the value of such gaps, yet one cannot help thinking that he has somewhat exaggerated their importance. However, we give this conclusion in his own words:—

"Believing that the causes that produced physical changes were much the same in former times as now, both in kind and intensity, (speaking generally, when spread over long epochs), *then the upheaving, contorting and dislocation of the strata, and the vast denudations they underwent before resubmergence, generally represent a period of time longer than that occupied respectively by the deposition of the formation disturbed, or of that which overlies it unconformably.*

"In the present state of our knowledge these things cannot be proved, but we may strongly suspect them to be probably true, and if they are so, then it follows that *the periods of time stratigraphically unrepresented during the Palæozoic epoch were much longer than those of which the various formations of that epoch bear witness.*"

2. A paper by Professor Rupert Jones on "Fossil *Estheriæ* and their Distribution" may be viewed as an abstract of, though differing somewhat in scope from, his "Monograph of the fossil Estheriæ" published by the Palæontographical Society. It is a very favourable specimen of philosophical palæontology, and shows that the diligent study of an apparently small subject may lead to large results.

Besides the endeavour to fix definitely the ages of the several deposits in which *Estheriæ* occur, by means of the little fossils themselves, assisted by concurrent testimony drawn from other sources, the chief object of the paper is to prove that the fossil *Estheriæ*, like their recent congeners, inhabited fresh and brackish water. The successful manner in which the author manages to dispose of apparently associated marine shells is not a little instructive, as it shows the necessity of scrupulously exact observations respecting the particular bed in which a fossil is found, most of these marine shells being shown to occur either a little above or a little below the *Estheriæ*; and the same with regard to crystals of salt. Even in the case of a *Lingula* occurring in the same bed as an *Estheria*, Professor Jones is at no loss, for he finds that the *Lingula* "in successive beds appears smaller and smaller in size, until it is dwarfed and disappearing, when *Estheria minuta* comes in; as if more and more fresh water invaded the area, unfavourably to the *Lingulæ* and ultimately bringing in the *Estheriæ*."

3. The relation of the Permian fauna and flora to those of the Carboniferous period has of late years been fruitful of discussion, most geologists being now inclined to regard the Permian as the concluding portion of the Carboniferous epoch.

In a paper on the Lower Carboniferous Brachiopoda of Nova Scotia, Mr. Davidson gives an excellent account of the present state of this question, and adds many new facts in favour of the view that the Permian is not really a group distinct from the Carboniferous.

Sir R. I. Murchison also enters somewhat fully into this question in a paper on the Permian rocks of Bohemia; but, were it not for the proverbial affection which every father bears towards his own children, it would be difficult to understand why this veteran geologist should so strenuously oppose a view which, besides being supported by nearly all the geologists and palæontologists who have specially studied the subject, appears scarcely assailable by arguments drawn from stratigraphical details, but must be decided by means of the fossils.

4. The next paper especially worthy of notice, is that by Mr. Jamieson, on the "Origin of the Parallel Roads of Glen Roy," a question which, as everybody knows, has hitherto baffled, more or less, every attempt at its solution.

The view advocated by Mr. Jamieson was suggestively propounded by Agassiz many years ago, but has been until now almost ignored. According to this theory, the "parallel roads," or terraces, are the beaches of glacier-lakes; and Mr. Jamieson finds that it is the only one which will account for all the facts, and which is not inconsistent with collateral phenomena. He also brings forward some new facts in corroboration of Agassiz's theory, especially the coincidence between the heights of the lines and those of certain "cols" (the latter being, strictly speaking, a few feet the lower), and the evidences of glaciers having formerly blocked up the mouth of Glen Roy.

Now, the existence of a glacier-lake depends, firstly, upon that of a glacier damming up the mouth of the valley; and, secondly, upon there being no other outlet for the water.

The following may, therefore, be considered the sequence of events described by Mr. Jamieson:—

Glaciers from the Great Glen, Corry N'Eoin, Glen Treig, &c., blocked up the mouths of Glen Roy and Glen Spean, the last-mentioned glacier projecting into Glen Roy, and thus cutting off the connection of that valley with the "cols" just noticed; accordingly a glacier-lake was formed in Glen Roy, and the beach forming the uppermost line was deposited; the Glen Treig glacier then shrank so as to open out the higher col—that of Glen Glaster—thus causing the lowering of the level of the water in Glen Roy; and then the middle terrace, or road, was deposited; the Glen Treig glacier then shrank again, until it withdrew out of Glen Spean, and that valley being now clear, the water escaped at Makoul; then, at about the level of that outlet, the lowest terrace was deposited.

In a similar manner Mr. Jamieson accounts for the "roads" in certain smaller glens; and he also shows why some of them stop or are indistinct at certain points; and, altogether, his explanations are so simple and so natural that the inducement is very great to believe that this much-debated question is at last settled.

5. River-action is illustrated in a most interesting paper, by Mr. Fergusson, on "Recent Changes in the Delta of the Ganges," and also in another on the Nile, by Dr. Leith Adams. Mr. Fergusson begins by enunciating certain principles of river-action, the first of which is, "all rivers oscillate in curves, whose extent is directly proportionate to the quantity of water flowing through the rivers;" but a certain looseness in the author's mode of expression renders it necessary to be careful not to give a too literal interpretation to some of his sentences; for instance, in this particular case, he evidently means to say that this principle is true when *all other conditions are equal*, for shortly afterwards he observes, that the extent or radius of the curves (*cæteris paribus*, understood, as before) is "directly proportioned to the slope of

the bed of the river." After illustrating these propositions, he next discusses the tendency of rivers flowing in alluvial soils to raise their banks, and thus to confine themselves in their beds ; and he explains the process by means of which this result is brought about somewhat differently from Sir Charles Lyell and other writers, as he calls in the aid of "backwaters," or large bodies of still water in the low lands beyond the banks of the river, the effect of their existence being that the overflowing water of the river is forced to deposit its silt as soon as it meets them, which is, in the wet season, soon after it leaves the river. In the particular case of the Ganges, Mr. Fergusson is doubtless right ; but it is extremely hazardous to generalize from a solitary instance. The secular elevation of deltas, and many other interesting subjects, are then treated ; and the author also describes in detail the principal changes that have taken place, during the historic period, in the delta of the Ganges ; that is to say, the changes in the courses, directions, outlets, &c., of the various rivers, the alteration in the slope of their beds, and many other phenomena, all showing the magnitude of the results brought about by river-action, and the rapidity of the changes, as well as the mutual dependence of the different rivers of the same valley. Indeed, we may consider that in the Valley of the Ganges there is being played a natural game of chess on a gigantic scale ; the valley itself is the chessboard, the rivers are the pieces, while the producers of the changes—water and mud—are the players. The effect of a move of any particular river in any direction in altering the relations of the rest, and the many other ways in which the connection of the various rivers is shown, together with the laws which regulate these changes, and river-action generally, are very curious, and deserve more attention from the geologist than they have hitherto received.

The chief object of Dr. Leith Adams's paper is to prove that the Nile has at a comparatively recent period flowed at a much higher level than it now does, at any rate north of the second cataract. The evidence upon which this conclusion rests consists chiefly of the occurrence of fluviatile shells at high levels. These shells were found in beds of alluvium forming terraces on the banks of the river, and they belong, according to Mr. S. P. Woodward, to six species, namely—*Unio lithophagus*, *Cyrena fluminalis*, *Ætheria semilunata* (Nile oysters), *Iridina Nilotica*, *Paludina bulimoides*, and *Bulimus pullus*. The first species is doubtful, the next four all live in the Nile at the present day, and the last probably occurs in the neighbourhood. They were found at all heights, up to *at least* 120 feet above the highest Nile of the present time.

Dr. Adams gives a sketch of the physical structure of the Nile Valley, and notices the collateral evidence in support of his conclusions to be derived from the position of ancient temples, tombs, and other monuments, striving to prove not only that the Nile above the second cataract formerly flowed at a much higher level than it now does, but also that the primæval river was much larger and more rapid than the Nile of the present day.

This paper is certainly an important contribution to the history of the Nile; but it should not be forgotten, although it appears to have been almost lost sight of, that Russegger discovered fluviatile shells at high levels in the Nile Valley more than five-and-twenty years ago.

6. Much light has been thrown upon the geology of the West Indian Islands in two papers (or, rather, two parts of one paper) by Dr. Duncan "On the Fossil Corals of the West Indian Islands," and one by Mr. J. Carrick Moore "On some Tertiary Shells from Jamaica."

Many years ago Mr. Carrick Moore suggested that the separation of the Caribbean Sea from the Pacific Ocean was not so complete in early Tertiary times as it now is, and the chief result of the papers just mentioned is that they prove, almost to demonstration, that this separation was not complete until long after the commencement of the Tertiary period.

It may be useful to give a synopsis of this argument, as it is an extremely good specimen of the manner in which the palæontologist infers the character and the date of changes that have occurred on the surface of the earth in geological periods. In most of the West Indian Islands certain strata occur containing shells and corals which, at first sight, appear (especially the shells) to resemble those now living in the Caribbean Sea; but, when closely examined and compared, they are found to be nearly all distinct. Furthermore, a careful comparison of them with recent fossil species from different localities shows that, while many of them resemble or are identical with species found in the Miocene beds of Europe, others bear the same relation to forms now living in the Pacific Ocean, a very small proportion (especially of corals) being allied to, or identical with, Caribbean species. It therefore follows, granting the usual postulates of palæontology, that the deposits are approximately of the age of the Miocene beds of Europe, and that, at or about the time when the animals lived, the remains of which occur fossil in these strata, there was free communication between the Pacific Ocean and the Caribbean Sea.

Dr. Duncan also discusses many other interesting points, such as it can easily be understood the determination of no fewer than 76 species of fossil corals from such a region would suggest to the mind of a palæontologist; but it is here quite impossible to do more than draw attention to his valuable papers.

7. The Abbeville jaw and the associated flint implements have attracted so much attention, and the circumstances attending their discovery have already been so often explained, that a knowledge of them may be fairly assumed in discussing Mr. Prestwich's paper "On the Section at Moulin Quignon, Abbeville, and on the peculiar character of some of the flint implements recently discovered there." It is absolutely refreshing to read a paper in which the identical pit in which the jaw was found is described, but which contains merely a few passing allusions to that redoubted relic of, possibly, man's antiquity, but, much more probably, of his cupidity and deceitfulness.

The question of the authenticity of the jaw and of certain associated flint implements is as complicated as that of Schleswig-Holstein itself, and is still less likely ever to be satisfactorily settled. Even the author of this paper, one of our most competent observers, after devoting several pages to the endeavour to prove the authenticity of the flint implements, appends a postscript to his communication for the purpose of stating that he is now convinced of their fraudulent nature,--an opinion, by-the-bye, which he originally held. So also Dr. Falconer and others have first been advocates of one view, then of the other, and sometimes have gone back again to their original opinion.

Setting aside the jaw and the flint implements, Mr. Prestwich's paper has an independent value, on account of the lucid discussion it contains respecting the manner in which the gravels of the Valley of the Somme were deposited. The author gives theoretical sections of the valley at the time of the formation, and at that of the emergence, of the high-level valley-gravels, as well as at the time of the formation of the lower-level valley-gravels, and an actual section of the valley at the present time; he thus shows that the high-level gravels are the older; that the valley has been chiefly formed by the river itself, from which also and from floating ice the gravels and loess were deposited; and that, whatever difference of opinion may exist respecting certain flint implements, others, the genuineness of which cannot be questioned, have been found *in situ* from time to time during the last fifteen years, in some of the oldest of the high-level gravels of the ancient Valley of the Somme.

8. The geology of the Eastern Archipelago is illustrated by three papers, two of which, namely, "On the Geology and Mineralogy of Borneo and the adjacent Islands," by M. de Groot, and "Notes to accompany some Fossils from Japan," by Captain Bullock, are merely explanatory notes sent with specimens, while the third—"On some Tertiary Mollusca from Mount Séla, in the Island of Japan," by Mr. H. M. Jenkins,—is a description of some of the specimens referred to in the first-named communication.

As Mr. Jenkins observes, Java has hitherto been a *terra incognita* to the geologist, and it is therefore interesting to have, at last, a definite age assigned to some of the Tertiary beds of that island, with the data before us upon which the conclusion rests. The author considers the fossils he describes to be of late Miocene date, though they have until now been considered Eocene, but not upon any very tangible grounds; he also discusses several questions arising out of a consideration of these Javan specimens, endeavouring to show that some portion of the so-called Nummulitic formation of India is also Miocene, in this view being supported by Dr. Duncan in a note on the Scindian fossil corals. He also advances the hypothesis, not without a certain amount of evidence in favour of it, that the Miocene fauna of the middle and south of Europe emigrated eastwards into the Indian Ocean. Basing his argument upon this view he strives to show that, with a representative fauna (on the principle enunciated by Professor E. Forbes), a series of Tertiary beds in the east would be newer than their apparant equivalents in Europe—a conclusion which is very important if it be true, but which at present requires confirmation; the same may also be said of the assertion that a tropical representative of the Pliocene formation of Europe could not be distinguished from a late Miocene formation.

Among the many meritorious papers of less general interest may be mentioned the following:—"On the Middle and Upper Lias of the Dorsetshire Coast," by Mr. E. C. H. Day; "On some Ichthyolites from New South Wales," by Sir P. G. Egerton; "On a Hyæna-den at Wookey Hole," by Mr. W. Boyd Dawkins; "On the Original Nature and Subsequent Alteration of Mica-schist," by Mr. H. C. Sorby; "On a new Species of *Dendrerpeton* and on the Dermal Coverings of certain Carboniferous Reptiles," by Dr. J. W. Dawson; "On the Upper Old Red Sandstone and Upper Devonian Rocks," by Mr. J. W. Salter; "On the Older Rocks of Bavaria and Bohemia," by Sir R. I. Murchison; "On the Skiddaw State Series," by Professor R. Harkness; with many others.

Judging from the number of new Fellows elected during the past year, the society must be in a very flourishing condition. We notice the following well-known names among those of the newly-elected Fellows:—Il Commendatore Devincenzi, Minister of Agriculture and Commerce of the Kingdom of Italy; Nicholas Kendall, Esq., M.P., Member of the Royal Commission of Mines; the Rev. Charles Kingsley, M.A., Professor of Modern History in the University of Cambridge; James Fergusson, Esq., F.R.S., author of the History of Modern Architecture, &c.; J. F. Iselin, Esq., M.A., Inspector of Science-Schools; E. J. Routh, Esq., M.A., Fellow of St. John's College, Cambridge.

A Class of foreign correspondents—to include not more than forty foreign geologists—has lately been instituted, and the lists of those already elected include the names of very many foreigners of note.

THE MICROSCOPICAL SOCIETY.

Dr. Lionel Beale has, during the past quarter, read before the members of this Society a paper of such great interest to physiologists, that we feel justified in devoting the chief portion of our limited space to an account of its leading features. It will no doubt be reported in detail in the 'Quarterly Journal,' devoted to the progress of Microscopical Science.

In continuation of his reports on this and kindred subjects, Dr. Beale communicated a very valuable paper on the Germinal Matter of the Blood, with remarks upon the formation of Fibrin. The author described all germinal matter as being soft or semifluid, and always of the spherical form, unless otherwise distorted by external agency. White blood-corpuscles, and the numerous small colourless corpuscles which Dr. Beale described in a former paper to the Society, consisting principally of living or germinal matter, are of a spherical form. In the blood of man and the higher animals, and we may add in the fluids of nearly all Invertebrata also, there exist a great number of these minute granular particles, of the same general appearance and refractive power as the matter of which the white blood-corpuscles are composed. It has been shown that both the red and white corpuscles of the blood vary very considerably in size; and Dr. Beale has satisfied himself that some, if not all the minute granular particles described by him, grow into white and red corpuscles. He also sees no reason why corpuscles may not exist in the blood, of such a size as to be actually invisible to the human eye, even when assisted with the powerful adjunct of a $\frac{1}{25}$th objective. The granular particles absorb nutriment from the medium in which they float, and undergo numerous subdivisons, producing other similar granules destined to become blood-corpuscles. The motive power which enables the granules thus to subdivide, has no connection with the nucleus or nuclear matter, but resides solely in the so-called "basis-substance," which is the semi-transparent matter forming the mass of the cell. This "basis-substance" is not a simple fluid, but consists of very minute, colourless particles, free to move upon each other; and Dr. Beale believes this motive-power to be an inherent and peculiar property of living matter. In cases of inflammation, as, for instance, where the capillaries in the foot of the Frog are thus affected, the germinal matter is more able to absorb nutrient substance on account of the retarded circulation. Hence it is that white corpuscles are so abundant in vessels subjected to inflammatory action, masses of clot having been observed, which consist of little else but white corpuscles. The author, however, does not consider that this development from granules of germinal matter is the only mode in which white blood-corpuscles are formed. In the development of the blood-vessels, the general opinion is that cells become stellate, and that the processes formed by the contiguous cells meet together; and thus, it is conceived, the cavities of the adjacent cells become connected together by tubes. Dr. Beale has already contested this inference and endeavoured to show that, so far from any coalescence between cells taking place, the communicating tubes, which are, of course, the incipient blood-vessels, are formed by the separation or moving away from each other of "cells" which were originally contiguous. The walls of the tubes thus formed contain germinal matter, which is supposed to be not unfrequently detached in small masses, thus giving rise to small corpuscles of a similar nature to that of the white corpuscles. The increase of the production of white corpuscles is favoured in all conditions in which the access of pabulum to these masses of germinal or lining matter is increased. In connection with this view of the production of blood-corpuscles, Dr. Beale has been led to a theory of the origin of exudations, which differs both from that held by those who support the "exudation theory," and those who uphold the "cell theory." He considers that portions of the granular bodies in the blood may pass through the walls of capillary vessels, and then being surrounded by a suitable pabulum, increase and multiply by subdivision, producing sometimes clear fluids, at other times viscid, corpusculated masses.

The question of the coagulation of the blood, which has been so much and so variously agitated of late, is also touched upon by the author. When discussing the anatomy of the red blood-corpuscles in a former paper he endeavoured to show that the coloured matter bears to the colourless or living germinal matter the same relation as formed material in other cases bears to germinal matter. It is formed from it, or rather results from changes occurring in it. If the living or germinal matter die, slowly and naturally (as when in the circulating fluid of the body), the red colouring matter is one of the substances resulting from its death. Numerous facts render it almost certain that these and other masses of germinal matter give rise to different substances, according to the conditions under which the particles cease to exhibit vital phenomena. The production of the material we know as fibrin is due to the death of minute particles of the living matter of the white and small colourless corpuscles, which takes place, under ordinary circumstances, when blood escapes from the vessels of the living body; in fact it is one of the consequences of the first decomposition which the blood undergoes after death. Such decomposition may occur, under certain circumstances, in the body itself. The action of ammonia on the blood, after death, is considered by Dr. Beale to be such as to keep the fibrin once produced in a state of diffusion throughout the mass; but he by no means considers its presence in the living blood as demonstrated, regarding, as he does, the theory he has propounded sufficient to account for the phenomena of coagulation without its interpolation. Neither is Dr. Beale at all inclined to assent to the views of Professor Lister, whose researches he, however, mentions with great deference. The theory propounded by that gentleman, that living substances, such as the walls of blood-vessels, &c., have not the power of separating fibrin from the blood, while external matters of an inanimate nature possess that property, is, he observes, unwarranted by our present knowledge, such an assertion as to the properties of living and inert bodies being as yet unsupported by conclusive proof. At the conclusion of his paper Dr. Beale remarked upon the unfairness displayed by those engaged in writing reviews upon the works of observers in this country—who, he says, are too wont to dwell upon the observations of foreign investigators to the neglect of those of their own countrymen.

Dr. Lander, of the Royal Navy, has communicated a paper on Marine Diatomaceæ found at Hong-Kong, with descriptions of new species. The species described belong to the genus Chætoceros—and are very abundant in the harbour of Hong-Kong. Several species are enumerated.

Mr. D. E. Goddard has described a new form of mounting-table. It consists of a piece of brass 12 inches long and 3 inches broad and $1\frac{1}{8}$th of an inch thick, a large space is punched out in the centre of the usual form of microscope slides. The table is supported by four legs, and a spirit-lamp can be placed beneath, thus enabling the operator conveniently to moderate the amount of heat used. The table is likely to be much employed by those who indulge in such accessory apparatus, though it cannot be said to be a necessary or even an important piece of mechanism.

THE ROYAL SOCIETY.

The papers read before the Royal Society during the past quarter have been of their usual varied character. They embrace the whole circle of the sciences, but the communications to which we shall chiefly allude in these pages are those relating to natural and physical science. Among these we find one of a very abstract nature, "On the Condition, Extent, and Realization of a Perfectly Musical Scale on Instruments with Fixed Tones," by Mr. Ellis. It was a very recondite paper, which could only be made intelligible to those profoundly acquainted with the science of music and by the help of extended diagrams.

Chemists have taken but a small share in the proceedings of the Royal Society this quarter. Dr. Stenhouse contributed a short paper on Rubia munjista or the Madder of the East Indies, in continuation of a paper communicated to the Society last year. Among the new facts contained in this paper was the analysis of the colouring principle of East India madder, to which Dr. Stenhouse has given the name of *Munjistine*. He found it to be closely allied in composition to the colouring matters obtained from Turkey, and Continental madders. Munjistine, though existing in larger quantity in Munjeet, than Alizarine in the best Naples madder, has unfortunately much less tinctorial power, and consequently the value of East India madder as a dye stuff is much smaller than that of either Turkey or Naples. From the purpurine of munjeet Dr. Stenhouse has produced a new dye, by dissolving it in ammonia, and allowing the solution to rest in a warm place for about a month, occasionally replacing the ammonia and water lost by evaporation. The purpurine disappears, and a new colouring matter is formed which dyes unmordanted silk and wool of a fine rose colour, but will not dye even mordanted vegetable fibre. The author gives the name *purpureine* to this new dye.

A paper of great scientific interest on the Acids of the Lactic series was communicated by Messrs. Frankland and Duppa.

Terrestrial magnetism now attracts a large share of attention, and the results of the observations made will some day lead to important consequences. At present we must reckon among the curiosities of science, the mysterious connection which seems to exist between the magnetism of our earth and the spots on the sun. Dr. Wolf, of Zurich, has gone over a table of the magnetic variations observed at Greenwich for several years, and compared it with his own observations of sun-spots, finding the years which show the greatest magnetic deviations to have been richest in sun spots.

The beautiful self-recording magnetographs at Kew have been adopted in the Observatory at Lisbon, and Señhor Capello, of the Lisbon, and Mr. Stewart of the Kew, Observatories, now send to the Royal Society the results of a comparison of certain traces produced simultaneously at the two places, during the magnetic disturbances in July last year. It seems that when the Kew and Lisbon curves are compared together, a very striking similarity is found to exist between the horizontal force, one perhaps less striking between the declination curves, and very little likeness between the vertical-force curves. The curves of vertical force are indeed nearly quite dissimilar. The peaks and hollows of the Kew curves were generally (simultaneously) reproduced at Lisbon, but in an opposite direction, a sudden augmentation of the vertical force at Kew corresponding to a diminution at Lisbon, and *vice versâ.*

When Captain Maguire was at Point Barrow during the winters 1852-53 and 1853-54, he made hourly observations of the magnetic declination. Similar observations were made by Captain (now Sir Leopold) M'Clintock, at Port Kennedy, 1,200 miles distant from Point Barrow, during the winter 1858-59. The learned President of the Royal Society, who may be considered the parent of this branch of science, has compared the results of these two series of observations in a paper communicated to the Society. The first point established is that the action of any disturbing force on the declination-magnet is less at Port Kennedy than at Point Barrow, that is, less at the station nearest to the points of 90° dip. The indication accords with the fact of the greater frequency of the aurora at Point Barrow. A remarkable correspondence is pointed out between the maxima of easterly and westerly deflection observed at the two stations. The maximum of easterly deflection occurred at the same hour of *absolute* time, the maximum of westerly at the same hour of *local* time. At Port Kennedy the normal direction of the magnet is 35° east of south : at Point Barrow 41° to the west of north : the contrast at the two stations is therefore nearly as great as can exist in any part of the globe, wanting only 6° of 180°, or of being diametrically opposite.

A few anatomical papers have been communicated during the past quarter. Mr. R. Lee contributed a paper on the Distribution of the Nerves in an Anencephalous Fœtus which he dissected, and in which he found the distribution quite normal. Professor Huxley made a communication on the Osteology of the genus Glyptodon. Mr. J. W. Hulke sent a contribution on the Minute Anatomy of the Retina of the Amphibia and Reptiles.

The last consisted of descriptions of the intimate structure of the retina of the Frog, Black and Yellow Salamander, Turtle, Land and Water Tortoises, Spanish Gecko, Blindworm, and Common Snake. In all seven layers are recognizable. Reckoning from the outer or choroidal surface of the retina these are: the Bacillary, the Layer of Outer Granules, the Inter-granular Layer, the Layer of Inner Granules, the Granular or Grey-nervous Layer, the Ganglionic Layer, and that of the optic nerve-fibres. The elements of the Bacillary Layer are remarkable for their large size, they are the bodies known as the Rods, and the Cones or Bulbs. There are good grounds for believing them to be the percipient elements. They consist of two segments, an outer or shaft, and an inner or body, the junction of which is marked by a bright transverse line. The shaft is a long rectangle in the rods; smaller and slightly conical in the lines. The body is flask or spindle shaped, and mostly smaller than the shaft in the Rods; more decidedly flask-shaped and larger than the shaft in the Cones. One of the "Outer Granules" is always associated with the inner end of the body in both Rods and Cones, and may be regarded as an integral part of it; the number of "Outer Granules" consequently equals that of the Rods and Cones. These "Granules" are large circular cells, mostly containing a central nucleus in which they differ from the "Inner Granules." A very delicate fibre runs inwards from the inner end of the Rod and Cone body, not from the Outer Granule enclosed in this, as some think. This Mr. Hulke has traced through the intermediate layers to the inner part of the Granular Layer in the neighbourhood of the Ganglion cells. The "Inner Granules" are round or polygonal cells, more numerous than the "Outer Granules." The Ganglion cells are mostly multipolar; some of their processes join those of neighbouring cells, others join the bundles of optic nerve-fibres, and a third set bend outwards into the Granular Layer. In the Frog and Gecko Mr. Hulke has traced optic nerve-fibres passing outwards through Ganglionic into the Granular Layer. The author prefers the term Granular to that of Grey-nervous for the broad layer which lies between the Ganglionic Layer and that of the Inner Granules, as it correctly describes its appearance under a low power, and has no respect to the nature of the tissue, which he regards as connective and not nervous. A high power demonstrates a closely-woven web in part derived from the fibres traversing it in a radial direction discovered by Müller. The Inter-granular Layer he also regards as a looser web of coarser connective tissue. The orderly arrangement of the respective layers and of the cell-elements in each is maintained by a framework of connective tissue, which consist of a homogeneous membrane bounding the inner surface of the retina; of the system of fibres discovered by Müller, arising from the outer surface of this membrane and traversing all the layers in a radial direction to end upon the inner surface of a fenestrated homogeneous membrane, which receives the Rod and line-bodies; and lastly, of a delicate web in connection with these fibres, which preserves the disposition of the cells when in the several layers. These radial fibres are not looked on by the author as the link between the Rods and Cones, the percipient, and the optic nerve-fibres, the conducting elements of the retina: the view held by Müller, Kölliker, and some others. The true link he considers to be the fibre passing inwards from the inner end of the Rod- and Cone-body, which also has a radial direction, but is to be distinguished from Müllers' fibre.

Another paper of mixed chemical, physiological and optical interest was communicated by Professor Stokes. It has been supposed that biliverdin, the green colouring matter of bile, and chlorophyll, the green colouring matter of plants, are identical. An optico-chemical analysis of these bodies, however, shows them to be perfectly distinct. Chlorophyll is a compound body—a mixture of four substances—two yellow and two green, all possessing distinctive optical properties. It is extremely difficult to separate these bodies by chemical means, but they may be obtained in approximate state of purity. The phyllocyanine and phylloxanthine of Frémy, Professor Stokes shows to be what we may call products of decomposition.

A very valuable account of some Experiments made to determine the effects of impact, vibratory action, and a long-continued change of load on wrought-iron girders was contributed to the Royal Society by Dr. Fairbairn. The experiments were undertaken in order to ascertain the extent to which a bridge or girder of wrought iron may be strained without injury to its ultimate powers of resistance, or the exact amount of load to which a bridge may be subjected without endangering its safety.

To give tables of the experiments would occupy too much space, but we may give the results arrived at. It follows from them that wrought-iron girders of ordinary construction are not safe when submitted to violent disturbances equivalent to *one-third* the weight that would break them. They, however, exhibit wonderful tenacity when subjected to the same treatment with *one-fourth* the load; and assuming that an iron-girder bridge will bear with this load 12,000,000 changes without injury, it is clear that it would require 328 years at the rate of 100 changes a day before its security was affected. It would, however, Dr. Fairbairn adds, be dangerous to risk a load of *one-third* the breaking weight upon bridges of this description, as according to the last experiment, the beam broke with 313,000 changes; or a period of eight years, at the same rate as before would be sufficient to break it. But the same beam had before been submitted to 3,000,000 changes with one-fourth the load, and it might be that during these experiments it had undergone a gradual deterioration which must some time, however remote, have terminated in fracture.

The girder experimented on, we may add, was a wrought-iron plate beam of the ordinary form, having a sectional top area nearly double that of the bottom.

An abstract of an abstract would give a very imperfect notion of the ideas propounded by the Rev. Joseph Bayma "On Molecular Mechanics," a new science, by which the author proposes to solve, "a problem which includes all branches of physics, and which may be enunciated in general terms, as follows:—

"From the knowledge we gain of certain properties of natural substances by observation and experiment, *to determine the intrinsic constitution of these bodies, and the laws according to which they ought to act, and be acted upon in any hypothesis whatever.*" There is no explaining a science like that of "Molecular Mechanics," as succinctly as Mme. De Stael once requested some German philosopher to explain his system—"*Dites-moi votre système dans un mot.*" We must wait for the author's volumes.

Two short papers, one by Mr. Prestwich "On some further Evidence bearing on the Excavation of the Valley of the Somme by River Action;" and another by the Rev. S. Haughton, "On the Joint System of Ireland and Cornwall," make up the geological contributions to the Royal Society during the first two months of the present year.

THE ROYAL INSTITUTION OF GREAT BRITAIN.

The scientific lectures at the Royal Institution have been of varied interest. In the first, on January 22, Mr. Grove, Q.C., gave an account of those curious experiments "On Boiling Water," which are now well known to all scientific men. Mr. Grove's experiments are confessedly but a continuation of those of M. Donny, of Brussels, who found that when water has been deprived of air, it no longer boils in the ordinary sense of that word, but exhibits the singular phenomenon of an occasional burst of vapour, the water in the intervals attaining a temperature higher than 212° Fahr. The principal result of Mr. Grove's investigations goes to prove the almost absolute impossibility of depriving water of all air; for however long, and under whatever conditions, water is submitted to heat, there is still found in it a very minute proportion of nitrogen. The lecturer hinted at some possible chemical connection between nitrogen and water, the preponderating substances on the surface of our planet, and the possibility of nitrogen not being merely the inert diluent it is commonly supposed.

Simple boiling, in the sense of a liquid expanded by heat into its vapour without being decomposed or having permanent gas eliminated from it, the lecturer believed to be unknown. Boiling (ebullition), therefore, is not the result of merely raising a liquid to a given temperature, but something much more complex.

To describe the experiments of Mr. Grove would occupy too much space, and we can only indicate the results, which went to show that chemical purity is a thing almost unattainable, and that in nature everything can be found in anything if carefully sought. Bromine when boiled, however long, always yielded oxygen; phosphorus invariably gave phosphuretted hydrogen; and sulphur, sulphuretted hydrogen, probably from the decomposition of water contained, which might lead to the supposition that a minute portion of oxygen, hydrogen, or of water is inseparable from these substances, and if boiled to absolute dryness, a minute portion of the gas would be left for each ebullition.

Mr. Grove further alluded to the effects of intense heat on simple and compound bodies, showing how the latter are decomposed, and the former undergo some molecular change, as phosphorus into its allotropic condition and oxygen into ozone. These facts showed that the effects of heat are not so simple as commonly supposed. In by far the greater number of cases, possibly in all, it is not mere expansion into vapour which is produced, but there is further a chemical or molecular change.

As regards the phenomenon of ebullition, Mr. Grove believes that no one has seen this take place without permanent gas being liberated, and that what is termed boiling arises from the extrication of a bubble of permanent gas, either by chemical decomposition of the liquid, or by the separation of some gas associated in minute quantity with the liquid, and from which human means have hitherto failed to purge it.

[These experiments of Mr. Grove probably explain the difficulty which working engineers have noticed of getting up steam with surface condensed water, and suggest the aeration of such water before it is again passed into the boiler. Mr. Grove asserts that water exposed to air takes it up as a sponge does water; but under some circumstances it may not absorb enough to produce steady ebullition.]

On January 29, Dr. Frankland lectured on the Glacial Epoch. As, however, this discourse will be treated at length in our Geological Chronicle, we shall content ourselves with a brief sketch of Dr. Frankland's physical theory. All our readers are acquainted with the evidences of glacier action on the surface of our earth, and the various hypotheses upon which the formation of glaciers has been explained. Dr. Frankland advanced a new theory, and conjectures that the sole cause of the phenomena of the glacial epoch was a higher temperature of the ocean, than that which obtains at present. Since the earth appears to be slowly cooling, it is conceivable that there was a time (not geologically distant) when the waters of the ocean existed in the atmosphere as aqueous vapour, as it may in Jupiter and Venus at the present day. After the formation of the ocean, the lecturer showed that the land must have cooled more rapidly than the sea. At this part of the subject, he alluded to some unpublished experiments of Dr. Tyndall, which prove the extraordinary intranscalency of aqueous vapour to rays of heat issuing from water. He showed also the comparative facility with which radiant heat passes from granite through most air. Thus we have a state of things tending much more to the conservation of the heat of the water, than to the retention of that of the land; and therefore, while the ocean retained a temperature considerably higher than at present, the mountainous regions of the earth had undergone a considerably greater refrigeration. The evaporation from the ocean would, therefore, have been greater than at present, and this increased evaporation must have been attended by increased precipitation, which would suffice to supply the higher portions of the land with that gigantic ice-burthen, which groaned down the mountain slopes during the glacial epoch. But as the oceanic temperature was higher, why was not the atmosphere warmer at greater elevations, and the snow-line raised? In answering this question, Dr. Frankland showed that the height of the snow-line essentially depends upon the amount of precipitation and accumulation of snow during the cold season, and not upon mean temperature. The mean temperature of land under extensive surfaces of snow must have been reduced, notwithstanding that the amount of heat in activity on the surface of the earth was greater during the glacial epoch than at present. The course of events, therefore, must have been as follows:—Whilst the ocean maintained a high temperature, the snow-line floated above the summits of the mountains; but with the reduction of the oceanic temperature it gradually descended, enveloping peak after peak, until, during the glacial epoch, it attained its lowest depression, whence it again rose, owing to diminished evaporation, to its present position.

On February 12, Dr. Wanklyn delivered a lecture "On the Synthesis of Organic Bodies," giving a brief account of the labours of Wöhler, Pelouze, Kolbe, and Berthelot, in this most promising and interesting department of chemical research.

On the 18th, Mr. Savory lectured "On Dreaming and Somnambulism in their relation to the Functions of certain Nerve Centres." The actions of the body are variously classed as excito-motor, sensori-motor, and ideo-motor, the nerve centres employed in these actions being particular parts of the brain. Sleep is to the brain what rest is to the other parts of the body, and dreams result from the imperfect exercise of the hemispheres when only in a state of partial repose. Somnambulism results from the activity of the sensorium while the hemispheres are at rest. Dreaming is more common than somnambulism, because the cerebral lobes are most liable to variation from the quantity and quality of blood supplied to them, and from the influence of stimulants, narcotics, &c. In profound sleep no actions but excito-motor, or involuntary, such as the movements of respiration and of the heart, are performed; and these are reduced in force and frequency. In dreaming, ideas are aroused, and impressions either subjective or objective are produced. If the latter, it shows that the sensorium must be in partial activity. In somnambulism, the actions are sensori-motory, and the sensorium is in full activity. The above is the merest outline of a very eloquent lecture, which was concluded by some observations on the beneficial moral effects that may possibly be derived from a study of our dreams. They may in fact become the means of showing us what we really are.

On February 26, Mr. Prestwich lectured "On the Quaternary Flint Implements of Abbeville, Amiens, Hoxne, &c.; their Geological Position and History." In his address (fully reported in our Geological Chronicle), the lecturer says he is convinced that the flint implements are the genuine work of man's hands, and that their being found along with the remains of extinct animals, necessitates bringing the date of these animals forward, as much as carrying back that of man. He believes we have no data to decide definitely on the age of these remains; but thinks we are not warranted in assuming the length of time alleged.

The interesting and important lecture of Professor Stokes, upon the "Discrimination of Organic Bodies by their Optical Properties," must for the present be postponed.

THE ZOOLOGICAL SOCIETY.

One of the most interesting papers communicated to this Society during this session, was by Mr Alfred Newton, on the discovery of a mummy of the Great Auk (*Alca impennis*), in Funk or Penguin Island, 170 miles north of St. John's, Newfoundland. It appears that ever since the publication of Mr. Yarrell's 'History of British Birds,' containing his account of the Alca impennis, wherein was cited M. Audubon's statement that that species bred on an island in the neighbourhood of Newfoundland, the attention of British ornithologists has been directed to that colony, in the hope of obtaining thence specimens of this rare and curious bird. The Great Auk was known to the sailors engaged in the Newfoundland cod fisheries, as the Penguin, so far back as the year 1670, and the few that have been seen within the last sixty years or so, are spoken of as "Penguins." A Mr. Wolley had ascertained these facts, and feeling convinced that specimens of the bird were yet to be obtained, determined to work out its history. Meanwhile Professor Steenstrup published (Videnskabelige Meddelelser, 1855, pp. 33–116) an account of the Alca impennis, in connection with the discovery of its bones in great abundance on Funk or Penguin Island, by Herr Stuvitz. The author of the paper, Mr. Newton, feeling great confidence in Herr Stuvitz's statements, immediately set about corresponding with every one he could hear of in Newfoundland likely to assist him in obtaining any of these much-prized remains of the Great Auk. At last, after considerable delay, by the conjoint labours of the Rev. Reginald Johnson, of Fogo, and the Bishop of Newfoundland, Mr. Newton has succeeded in inducing Mr. N. R. Vail, a gentleman of scientific taste, to make application to Mr. Glindon, who is removing the soil from Penguin Island, on account of its containing large quantities of phosphatic manure, and who has ordered his men there employed to use their best endeavours to obtain the bones of the Penguin. Amongst numerous other remains, the mummy was found which Mr. Newton exhibited. It seems to have been deeply buried, being, says the Bishop of Newfoundland, "four feet below the surface, and under two feet of ice." The skeleton is not quite perfect; but when it is remembered what a rarity any bones of the bird are, and that the nearest approach to a perfect skeleton of the Great Auk, *viz.* that in the Jardin des Plantes, is wanting in many respects, the importance of Mr. Newton's discovery will be appreciated. Besides the skeleton in the Jardin des Plantes, there are two specimens of this bird in the Museum at Copenhagen—dissected with a view to show the various organs. In many museums specimens of bones from various parts of the body exist—as at Christiania, the Royal College of Surgeons, Berlin, and elsewhere. There are altogether sixty-three or sixty-four stuffed skins of the Alca impennis known to exist; many of these contained parts of the skeleton, which have in some cases been removed without injuring the skin. Mr. Newton expressed his intention of placing the specimen he had so perseveringly obtained in the

the hands of Professor Owen, from whom an account of the bird's osteology was anticipated.

Mr. A. R. Wallace has contributed a very interesting paper on the birds inhabiting the islands of Timor, Flores, and Lombock, with descriptions of new species. The chain of islands of which Timor is the last, extends along the east of Java, and forms a natural subdivision of the Malayan Archipelago. The soil of these islands is very dry; active volcanoes are still at work in them, and their origin is probably volcanic. The vegetation consists of spiny and prickly shrubs, the dense forests and luxuriant growths of most equatorial regions being quite unknown. During five months, Mr. Wallace obtained 112 species of birds from Timor—the number of species known altogether being 118; from Flores he obtained 86 species; from Lombock, 63 species; from Sumbawa no collection was made; and the island of Bali belongs to the Indian region, and is therefore not considered in connection with the Malayan groups. The total number of species of birds known to inhabit the Timorean sub-group is 186, and Mr. Wallace makes some interesting comparisons, from the data he has obtained, with the avifauna of the neighbouring islands, which he has so successfully investigated. The presence in the Timorese avifauna of a large number of Australian representative species, and the fact that the species peculiar to Timor approach the Australian types, though at the same time the Javan forms are very abundant and there are few birds of the Javan type which are not identical with species of that island, leads Mr. Wallace to infer that the island was more anciently populated from Australia, while the Javian forms have appeared later, and partially extinguished the Australian types. Timor is now nearly 20 miles by sea from Java, while 300 miles separate it from Australia. A large sandbank however extends from the north coast of that continent to within 20 miles of Timor, and Mr. Wallace believes it probable that this sandbank is owing to the submergence of the land not very long since. It is not likely that an absolute connection by land existed between Timor and Australia, since but one Marsupial, and that of a Moluccan type, is found in the island. Yet we must assume a much closer approximation to the continent, in order to enable us to understand how it happens that though the birds of these islands are, on the whole, almost as much Indian as Australian, yet the apparently endemic species have such a preponderating Australian character.

A list of birds from Damara land, collected by Mr. Anderson, has been communicated by Mr. T. H. Gurney. The same gentleman communicated a list of a small collection of birds from Huaheima, one of the Society Islands. The birds were obtained for Mr. Gurney by Mr. T. H. Wodehouse, H.B.M. consul at Raiatea.

Among the new species of Mammalia described before the Society during the past quarter, is a new squirrel from Natal, which Dr. Gray proposes to call *Sciurus ornatus*; also a new species of seal from the west coast of North America, which Dr. Gray has named *Halocyon Richardii.*

Mr. Flower has been dissecting the Echidna, which lately died at the Gardens in Regent's Park, and has communicated a paper on its cerebral anatomy. He finds that the *corpora quadrigemina* does not, as has been stated by Owen and others, differ materially in this monotrema from the ordinary structure of this part of the brain in other Mammals.

The fishes of the inland rivers and lakes of many countries are so little known, and the circumstances under which they exist are so varied and peculiar, that in nearly every district new and local species are to found. Captain Dow has lately transmitted to England a collection of thirty-one species obtained from Central America, among which Dr. Günther has determined several new species of great interest which he has described to the Society.

An addition to the 1,200 species of Helix is made by Dr. T. E. Cox, who describes a species from Port Denison, N.E. Australia, as *Helix Forbesii.* Mr. Frank Buckland, who has done such good work for our salmon and trout, and also tried to show us a live porpoise in London, has turned his attention to oysters, and has addressed a communication to the Society, in which he advocates the introduction of the American *Ostrea Virginica* into the seas of this country.

Mr. H. T. B. Hancock is performing some experiments on the supposed electrical powers of Octopus, by means of a specimen in the Society's gardens.

CHRONICLES OF SCIENCE.

I. AGRICULTURE.

Almost every department of farm management is in active operation during the first months of the year. Land drainage and autumnal tillage have put the fallows in the best condition for deriving fertility from the atmosphere. The direct application of manures to the crop becomes useful and economical as the season of growth commences. Seedtime brings under discussion the various methods at our command for plant improvement. The continuance of stall-feeding on winter food keeps the whole subject of the meat manufacture before the mind of the farmer. And the lambing and calving season recalls for his consideration all those points on which the theory and practice of the improvement of his live-stock depend. It is in the order of these several departments of farm practice that we write the agricultural record of the first three months of 1864.

1. A dry winter had very early in the season put the tillage work of our arable farms unusually forward; and the periods of severe frost which towards the end of winter were experienced have been of the greatest service on all well-drained clays. It is on such lands especially that the steam cultivation of the previous autumn proves superior to the ordinary horse tillage, which on such soils interferes very materially with the drainage of the land.

The extension of this steam cultivation is the great agricultural event of late years, and though comparatively little is heard of it during the winter months, yet it is then especially that its advantages are seen and realized. Fields which have hitherto been kept dry by steep surface lands or ridges and frequent intervening furrows, as well as by the ordinary underground drains, are now left flat and dry, torn up roughly before winter by the engine-drawn cultivator.

The drainage of stiff clay soils has, indeed, till now been rarely thoroughly effected. Trenches have, indeed, been dug some 3 or 4 feet deep and 7 or 8 yards apart, and through pipes placed in them it has been expected that all the rain which falls upon the field will find its way, after gradual penetration, through the soil and subsoil, and filtration by every particle of all this three or four foot deep mass of earth. But after this the upper layer of this mass has hitherto been cultivated in a way which interposes between it and the lower layers what is practically an impervious floor. Three or four ploughings of grain stubbles before the succeeding peas and beans, the passage of long teams of cattle on the floor over which the soil, and under which the subsoil lies is an effectual induration. This floor is fatal to land drainage, and therefore to fertility. It must be broken up, and this can be done effectually only by steam power. Every month of March for several years we have walked over hundreds of acres of stiff clay land—land needing four horses to the plough—drained and smashed up by steam power before winter, between whose surface and the drains no such floor exists. It has trodden dry, and has then been lying in as wholesome a condition as it is possible for land to exhibit at this season. The only tillage which it has had has been a one-way cultivation, or grubbing by steam power 8 or 9 inches deep during the previous dry weather of October or November. And this land has thus been left a treasure-box whose lock has been effectually picked, of whose stores, made thus accessible, it only needs that use be made by planting well-selected living seed, in order that the utmost fertility may be exhibited at harvest time. Steam cultivation, after drains have been dug and placed, is the way to ensure good drainage. Tillage by steam power, under such circumstances, is the true picklock by which the exhaustless stores of food for plants present in all clay soils, lying now inaccessible, may be laid open to the roots of plants. The breaking up of the floor, which horse cultivation lays immediately below the surface, and the breaking up of soil and subsoil, with the exposure of the whole to air and rain on its way downwards to the drain, will yet exert a marvellous influence on fertility. Hitherto the progress of events has been all to the advantage of the lighter soils. The use of guano and of artificial manures, and the extension of liberal feeding in the sheep-fold, have all been especially to the advantage of our sands and lighter loams. The application of steam power as the auxiliary of land drainage gives now the turn of advantage to the owners and occupiers of our clays; and whereas by marling, sheep-feeding, and artificial manuring the lighter soils have till now been foremost in the march of agricultural improvement, thus contributing more than any other to that increased produce of food which English fields have of late provided, we may now expect that by drainage and effective tillage the stiffer lands will take their turn in front, making the most rapid progress, yielding the largest produce, the most profit, and the highest rent.

All these considerations, and others connected with the best rotations of cropping for clay soils, were discussed at the meeting of the English Agricultural Society on March 16th, when Mr. A. Hughes of Thorness, Isle of Wight, read a paper on the Cultivation and Management of Clay Farms.

2. At a previous meeting of the same Society, Mr. Lawes of Rothamstead had read a paper on the Value of common Salt as a Manure. Its reputation as a fertilizer has, as he believes, hitherto stood too high. It has been said to increase the production of grain, and to improve the quality of straw. It is believed to have great effect especially on crops, such as mangold-wurzel, which are of marine origin. It is said to fix ammonia in the soil, and also to preserve moisture in dry seasons. Mr. Lawes's own experiments have satisfied him that it is of little use.

The two plots of land, A and B, on which these experiments had been tried had both received exactly the same amount of artificial manure, but A, unlike B, received, during 1851, 1852, and 1853, 3 cwt. of common salt per acre per annum in addition to the other manures. The parallel is exact with that exception. The mean produce of 1848, 1849, and 1850, the years previous to the application of salt, was 32¼ or 32½ bushels per acre in each case; showing that the crops of wheat were extremely alike. There was, in fact, no difference between them. Again, in 1851, 1852, and 1853, the years in which A received 3 cwt. of salt per acre per annum and B did not, the produce of wheat per acre was almost exactly the same. During the next ten years also the produce was again nearly alike. The produce of the sixteen years was in each case 37¼ bushels, showing that in the yield there was no trace whatever of the action of the 9 cwt. of common salt. Some persons think that, although salt may not increase the quantity of produce, yet it improves its quality. What, then, was the weight of the produce per bushel? In the first three years the weight was a little higher in A than in B; in the second three years, when the salt was applied—the difference was again slightly in favour of A, though not so much as it was before; and in the next ten years the weights per bushel were almost exactly alike. The total produce of the first three years was 5,988 lbs. against 5,976 lbs.—a difference of only a few pounds. In the three years when salt was used the produce was, as nearly as possible, the same; and in the ten years after salt was applied, the produce was 7,799 lbs. against 7,811 lbs.—again a difference of only a few pounds. In the total produce of the whole period of sixteen years the difference was only 12 lbs.—7,222 lbs. against 7,234 lbs. Salt is supposed to strengthen straw, and to improve its quality. In the first period, before salt was applied, there was 57 lbs. and a fraction against 56 lbs. of grain to 100 lbs. of straw; therefore A was in that case rather superior to B. In the next period there was 42·6 lbs. against 41·7 lbs., there being again a slight difference in favour of A. Practically there was no difference in the proportions of corn and straw, taking the whole period.

For mangold-wurzels, of which Mr. Lawes grows annually about 15 acres, he has been in the habit, which is prevalent, of applying a few cwts. of salt with the guano which he uses along with a half-dressing of dung. But an experiment last year showed that the crop was unaltered where no salt had been applied, and was diminished where a double allowance of salt had been added. Of course the experience of a single locality will not determine the truth for all England. But Rothampstead, in Hertfordshire, is sufficiently inland to make one expect that there the full effect of salt as a manure would be seen. Though, however, there are undoubted instances where salt has been applied with advantage as a manure, yet in an island such as ours, swept annually by Atlantic storms, it can rarely be the case that the common salt of the soil is the body *in minimo*, whose quantity, according to the accepted theory of manures, rules the crop.

A recent lecture on Artificial Manures, by Professor Anderson, the chemist to the Highland and Agricultural Society, has directed attention to the prices charged for Lawson's so-called phospho-guano, and for ordinary superphosphates. The phospho-guano, as sold, is the result of treating, with a comparatively small quantity of sulphuric acid, the natural rock deposit which is imported from Monk's Island and other islets in its neighbourhood. Certain reports, by Liebig, Voelcker, and Anderson, of the merits of this substance as a manure, which had been drawn up at the request of Messrs. Lawson to be used as affidavits in connection with a suit brought against them in the Court of Chancery, by Messrs. Thomson, Bonar, and Co., agents for the sale of Peruvian guano, have of late been largely used by them as a trade advertisement, and a good deal of angry feeling has been excited amongst the manufacturers of the cheaper superphosphates by this quotation of *ex parte* statements on high authority against them. The upshot of the discussion, which has been carried on chiefly in the columns of the Scottish agricultural journals, appears to be the admission, on all hands, that it matters not for the agricultural effect of it what may have been the origin, whether mineral or animal, of the soluble superphosphate of lime which exists in any manure; though as regards the remainder of the substance, which has not been acted on by the acid used, but remains in the original condition of neutral phosphate, it is a useful manure in the case of the Monk's Island deposit, and still more so in the case of bones, but it is entirely valueless in the case of the ordinary coprolite, which is the source of most of the cheap superphosphates in the market. The tendency of the discussion will undoubtedly tend ultimately to bring down the present high price charged for the phospho-guano, and assimilate it more nearly to the prices charged for ordinary superphosphate.

The imports of manuring substances during the past year, which have been lately published, show a considerable increase under the head of bones and guano, but a large diminution under the head of nitres. The figures are as follow:—

Imports.	1862.	1863.
	Tons.	Tons.
Bones, whether burnt or not .	67,230	77,492
Guano	141,636	233,574
Saltpetre	22,162	20,225
Cubic nitre	39,716	26,990

3. We come now to such facts of our current agricultural history as are classed under the general subject of plant growth. Perhaps the leading fact under this head is the growing conviction that, thanks to manuring and sheep-feeding on our light soils, and to drainage and better tillage on our clays, the fertility of the arable lands of this country has of late been rapidly advancing, while that of the pasture lands has been stationary. In Gloucestershire a recent inquiry, helped by the records of a Cotswold farm which had been kept for nearly a hundred years, led clearly to this conclusion. Wheat had on that farm doubled its produce per acre since the latter part of last century; barley and oats had not increased correspondingly; but green crops

had largely increased in productiveness, and a much larger quantity of meat is now made per acre than formerly. And this was found to contrast most glaringly with the condition of the dairy districts of the same county which do not now keep more stock, or yield more cheese, and butter, and bacon, than they used to do thirty years ago.

Another fact of some interest under this head, is the extension of the growth of flax during the past year. In Ireland, the following has been the acreage of this crop during some past years:—

	1860.	1861.	1862.	1863.
Acres of Flax .	128,444	147,866	150,312	213,992

The promotion of flax culture in England is creating a good deal of attention. And in many country towns, meetings have been held for the establishment of flax retteries, which, as offering a market for the produce, is necessary as a first step towards the extension of flax cultivation.

The subject of plant improvement, and especially that of our cereals, has been a good deal under discussion in our agricultural journals. Mr. Shirreff, of Haddington, to whom we owe many of our best sorts of wheat and oats, seems to consider that the work of plant improvement is exclusively natural, and that all that we can do is, in effect, to keep a sharp look-out, and whenever we see in any natural sort or variety the qualities we want, take care of the plant, and multiply it as fast as we can.

Mr. Hallett, of Brighton, on the other hand, who advertises at such enormous prices what he calls a "a pedigree" wheat, believes in the power of improving a plant by cultivation. He chooses a promising ear of Wheat—plants all the seeds—takes that plant of the series which is best—chooses its best ear—again plants all *its* seeds—again chooses the best plant, best ear, and best seed—and after a series of harvests thus obtained, during which, as he alleges, the plants and ears have annually improved upon his hands, he takes the ultimate produce as the parents of the grain which he shall offer for sale, and multiplies it by thin seeding and careful cultivation as fast as he can —and so by-and-by the "Z family," or some other of long lineage, is offered to the "faithful," for they alone will venture its price, at perhaps one or two guineas a bushel!

There is probably less difference between these gentlemen than they admit. Both select the best natural origin they can find—both are confident that the progeny will be like the parent—both believe in the fixity of character of the resultant grain; the one, however, thinking that the character is fixed in the origin, and the other, that it is fixed in the successive annual growths of the sort in question.

Neither will deny the immense folly of carelessness in the selection of our seed—and both may well wonder at farmers who when they want a good Cabbage, Mangold, or Turnip, take care to choose a good plant as the parent of the seed they use, yet the moment they approach the cereals, at once neglect the principle which in the other case they know to be efficient and correct.

A good deal of excitement has prevailed in Ireland and elsewhere, owing to an unusual liability on the part of the Swedish turnip to degenerate into a Rape-like plant, sending all its growth into leaf and stem and refusing to form a bulb. An action against the seedsman for damages, on the plea that the seed was at fault, resulted in a verdict for the defendant, the jury being unable to resist the evidence of the mischief being due to other causes. It appears that the circumstances of the soil may so differ in the same field that rows of plants, from seed sown out of the same seed-box from end to end across it, shall in some places exhibit uniformly good bulbs and elsewhere nothing but leaf and stem. It appears to us that even here a good deal of responsibility rests with the seedman, and seed grown from successive generations of well-selected plants would have that power of resisting the mischievous influence of circumstances and of producing good bulbs in spite of them, according to a long-continued habitude and bent, which Swede seed grown at hap-hazard is found to want.

Seed-time calls to our remembrance the invention of Mr. Smith's (of Woolston) capital combined seed drill and cultivator for draught by steam power. It is being extensively used this spring and will no doubt come largely into operation as a most efficient tool for sowing wheat upon a clean bean stubble, and even occasionally for planting beans upon a clean wheat stubble—certainly for sowing barley after the sheepfold—*at one operation.* It is the latest illustration that we have of the way in which steam power is applicable both to the economizing of farm labour and to the increase of its efficiency.

The character of the wonderful harvest with which England was last year blest, appears from the following classification of the reports regarding it from all parts of the country which have been published by the 'Mark Lane Express.' It will be seen what an immense preponderance of the reports regarding the wheat crop declare it to have been over average.

Reports.	Wheat.	Barley.	Oats.
Under average . .	5	55	65
Average	96	245	268
Over average . . .	523	261	200

4. We have now to refer to points connected with the meat manufacture. The high price of beef, mutton, and wool have all tended to promote in a wonderful degree the extension of the practice of high feeding, which has of late years enormously grown. No great increase of the imports of oilcakes, on which the chief dependence has been hitherto placed, seems from the following figures to be possible.

The following are the imports of Linseed and of Linseed cakes during the past six years:—

	1858.	1859.	1860.	1861.	1862.	1863.
Linseed . . qrs.	1,017,844	1,270,911	1,330,623	1,160,270	1,088,472	1,104,578
Oil cakes . . tons	80,629	95,208	108,826	113,725	101,156	88,566

On the other hand there is a growing conviction of the extent of fraud by adulteration, to which the purchaser of these cakes is liable. The consequence is a probably unprecedented consumption of home-grown grain; and to this the low prices of barley and of wheat have no doubt contributed. Whenever the price of grain or whole meal is one-eighth, or thereabouts, that of meat, it is profitable to use it as food for fattening stock. And of course there is a great additional advantage besides the mere sale at a good price of inferior grain which is derived from this method of their disposal. The enrichment of the manure which is thus affected is an additional profit of great value. To how large an extent this is made use of, let the following example suffice to show. It relates to a farm on the edge of Woking Common, over which we lately walked, where the soil is naturally extremely poor, but made wonderfully productive by a large consumption of purchased food for fattening stock. On about 500 acres of this poor sandy land, close on the edge of what may be called the dreariest waste in the island, a herd of 50 to 70 cows is milked for the London market; a dry flock of Hampshire Downs, varying from 200 to 400 head, is fed; and hogs, ranging in number from 1,500 to 2,000 per annum, are fattened up to 10 or 12 scores a piece. All this is done so long as meat and bacon are at ordinary prices, with a small profit; but the principal advantage no doubt is, that the naturally poor soil of the farm is thus made capable of growing 5 quarters of wheat, 5 or 6 of barley, and 30 to 40 tons of mangold-wurzel per acre. The swine, bought at 5 to 7 score a piece, are kept till 10 or 12, making meat at the rate of rather more than 1 lb. a day, and receiving half a peck of meal daily upon an average, *viz.* one-half barley meal, and the rest wheat, Indian corn, lentils, peas, beans, buck-wheat, or whatever else is cheapest.

Of course, with such a great quantity of stock to feed, purchases of food are very large; 500 up to 1,000 bushels of grain are used weekly; and the annual return of meat—12,000 lbs. of mutton, 150,000 lbs. of bacon, and about 40,000 gallons of milk—equal in all to 200,000 lbs. of meat per annum—amounts to a manufacture of 400 lbs. of meat per acre—which is, we believe, quite unparalleled.

The effect is seen in the high artificial fertility of this naturally poor land. The large quantity of rich manure, deep cultivation, and sheep-treading, are the three agencies employed, and their success, unaided, as in other pure sandy districts, by any possibility of marling or claying the land, has been unequivocal. No contrast is so great as that existing between the luxuriant growth of the fields on the

Hoebridge Farm, near Woking, and the utter worthlessness of the waste close by.

The principal point of recent interest, however, under our present head, during the present quarter, undoubtedly has been the introduction by the Government of the Bill for permitting the use of malt, free of duty, as food for sheep and cattle. Whatever the satisfaction with reference to this measure may be, taking it in some degree to indicate that the Government may hereafter be willing to reconsider the whole subject of the malt tax, there can be little doubt nevertheless that it is in the meantime an utterly worthless concession to the agricultural interest. There are cheaper foods already at our command than ever malt, duty free, will be—and the mixture of the malt with linseed meal, which is one of the safeguards which the Bill provides against those frauds against the revenue which it will facilitate, is no improvement of the material for use in either feeding-stall or sheep-fold.

5. The value of pure-bred stock in the market, which indicates their intrinsic merits in the eye of judges, has lately received a singular illustration in high prices realized at the sales at Towneley and at Sarsden of the short-horn herds which have grown up under the management of Colonel Towneley and the late Mr. Langston, M.P., respectively. The success of the former herd especially which has been in existence only during the past fifteen years, has been extraordinary. During that time more than 2,000*l.* have been won as prizes, besides 22 cups, 2 "challenge" cups, 26 gold medals, and more than 10 others of silver and bronze.

The only other point to be noticed in our present agricultural chronicle, is the excitement which prevails on the subject of contagious disease amongst our live-stock. Notwithstanding that the mischief is in all probability exaggerated, yet it is bad enough to justify a certain amount of interference and supervision by the Government; and a measure has accordingly been introduced into Parliament forbidding the turning out of stock afflicted with certain specified contagious diseases into public places; enabling the Secretary of State to forbid, if necessary, the removal of cattle or sheep from any infected district; and requiring all carriers to provide cleaned carriages for the conveyance of stock, &c. This, with another measure dealing in a similar spirit with imported live-stock, has been referred to a select Committee of the House of Commons.

It appears that we have 8,000,000 of cattle, 40,000,000 of sheep, and 4,300,000 pigs in the United Kingdom, and that the annual mortality by disease is 5 per cent. of the cattle, 4 per cent. of the sheep, and in Ireland 10 per cent. of the pigs. The total value of live-stock destroyed by disease last year is thus believed to have been 6,120,000*l.* In addition to this their owners had to suffer the loss of condition in the animals which have recovered, and the general public undoubtedly suffer considerably from the consumption of the meat of animals slaughtered when in a diseased condition. These appear to be sufficiently urgent reasons for Government interference.

II. BOTANY AND VEGETABLE PHYSIOLOGY.

The prizes offered by the French Academy in this department of science call attention to subjects of great importance in vegetable physiology, and are three in number; the first Bourdin prize, postponed from 1861 to 1866, March 31st, is for an essay to determine by anatomical research, if there exists in the structure of the stems of vegetables the characters belonging to the large natural families, and thus agreeing with those deduced from the organs of reproduction. Any comparative work on the branches and stems will be admitted to competition. Another prize, postponed from 1860, to September 1, 1865, and to consist of a gold medal, value 3,000 francs, will be given for the determination experimentally of the causes in the inequality of absorption by different vegetables of the solutions of the various kinds of salt which the earth contains, and to recognize by anatomical study of the roots, the connection which may exist between the tissues which constitute them, and the matter which they absorb or give out. A prize, also standing over from 1859, is now offered for 1866 "for the study of vessels of the *latex*, or proper juice, of vegetables, considered in a double aspect from their distribution in the different organs of plants, and particularly their affinities and connections with the lymphatic or spiral vessels, as well as with the fibres of the plant."

The prizes *awarded* in vegetable physiology at the annual meeting of the Academy, were, first, the *grand prize* of 3,000 francs, "to discover what the changes are which take place during germination in the constitution of the tissues of the vegetable embryo and perisperm, and in the matter which these tissues contain." Dr. Arthur Gris, assistant-naturalist to the Museum, obtained the award. The Barbier prize was equally divided between M. Jules Lepère, of Pondicherry, and M. Veillard, a naval surgeon; the first having presented a paper on the study of the different medicaments used in India, and comparisons of them with those which our European plants furnish; also, researches into the Hydrocotyle Asiatica, and its use in medicine. The second writer presented a work relating to the medicinal and alimentary plants indigenous to New Caledonia, throwing light upon the therapeutic use of vegetables as yet but little known, but studied in two most important colonies, by officers attached to the naval medical service of France.

A prize awarded for a chemical rather than for a botanical subject may be alluded to here. M. Bouffé received 1,500 francs reward for his natural green (*vert nature*), a mixture of picric acid and Guignet's chrome green, intended to replace the arsenical greens, so much sought after on account of their beauty and brilliancy, but so dangerous to the makers of artificial flowers.

While upon the subject of prizes we may mention that the Royal Horticultural Society of London, in order to foster the study of scientific botany, has offered the following prizes for botanical collections:—1. One silver and two bronze medals for the three best collections of dried wild plants of each separate county, classified according to the natural system. 2. Three gold medals for the best three of all the collections out of all the several county collections. These collections must be arranged according to a natural method, and be accompanied by a list arranged according to the same method, with the species numbered. The collector is to follow some work on British botany, such as Babington, Hooker and Arnott, or Bentham, stating the work adopted. The collections must be delivered on or before 31st December, 1864, to the Secretary of the Royal Horticultural Society. Further, the Society will present a gold medal to every exhibitor of a new species of plant found growing in the United Kingdom. We need hardly point out that these regulations offer an excellent opportunity to the members of the various Field Naturalists' Clubs which are scattered throughout the kingdom, and we anticipate that the stimulus thus publicly offered by the Royal Horticultural Society will be productive of the most beneficial results.

At the January sitting of the Academy of Sciences of Vienna, M. Ettingshausen exhibited a work about to be published under the title of 'Photographic Album of the Flora of Austria, being at the same time a Manual of Botany.' This is the first time that the photographic reproduction of vegetables has been attempted as a new and important means of botanical instruction. Hitherto it has been found impossible to obtain good photographs of plants, the images being black simple sketches without shade, on account of the green colour of the objects. Last year, the author, in giving an account of the recent progress of what he terms *autophysiotypie*, communicated to the Academy that at the Imperial Printing Office they had been able not only to obtain good photographs of plants, but also to engrave them so as to reproduce them by printing. The work above alluded to is the realization of this beautiful method. It embraces a complete selection of characteristic species of all the families of the Austrian flora, and interspersed with the text are the photographic portraits of hundreds of plants, just in the manner of woodcuts. M. Ettingshausen has also presented a memoir on the nervation of ferns, illustrated by the process of *autophysiotypie*.

Mr. J. Hill of Cambridge, Mass., gives an account of some observations upon the compass plant (Silphium laciniatum) which he found growing wild near Chicago, last autumn. The field had once been ploughed, and sowed with Timothy grass, and there was a grove a few rods to the east. Notwithstanding these unfavourable circumstances, he took a rough measurement of thirty plants, without selection, as follows:—Holding a card over each plant with its edge parallel to the central line of his own shadow, he marked upon the card a short line parallel to each leaf of the plant. Measuring afterwards the angle which each mark made with the edge of the card, and subtracting from each angle the azimuth of the sun for the estimated central time of observation, he obtained the following results. Only one plant, bearing four old leaves, gave an average angle with the meridian of more than 34° Their mean was 18° W. The remaining twenty-nine plants bore ninety-one leaves, which made with the meridian the following angles, *viz.*—Seven made angles greater than 35°; fifteen, angles between 35° and 20°; sixteen, angles between 20° and 8°; twenty-eight, angles between 8° and 1°; and twenty-five, angles less than 1°. Of the sixty-nine angles less than 20°, the mean is N. 33′ E., *i.e.* about half a degree east of the meridian. The error of azimuth, from want of means to determine the time accurately, may have been as much as three times this quantity. One half the leaves bore within about half a point of N., and two-thirds within one point. The magnetic declination was about 6° E., and the observations were made when the sun was about on the magnetic meridian.

Henna (Lawsonia inermis), a plant which has been so long used in Egypt as a cosmetic and dye stuff, has been introduced into commerce by MM. Gillet and Tabourin, of Lyons. According to the 'Coloriste Industriel,' the researches of these chemists show that the active colouring principle is nothing more than a peculiar kind of tannic acid, which they propose to call *hennatannic* acid. The dried leaves of henna contain half their weight of this substance. The plant is, it appears, particularly useful for imparting to silk the different shades of black, the colours so obtained being very beautiful and permanent.

At the Academy of Sciences of Vienna Dr. de Vry exhibited some beautifully-crystallized resin of the upas tree (Antiaris toxicaria), also the upas poison itself in a crystallizable state. He regarded the poison as a Glycosite, that did not act upon the stomach as a violent poison, perhaps not as a poison at all, and possessed poisonous properties only when brought into immediate contact with the blood. He had convinced himself by repeated personal experiment that the stories of the poisonous atmosphere of the upas tree are fabulous.

Further investigations into the milk vessels of Leontodon (the common dandelion) by Dr. August Vogt, of Vienna, show that the intercellular substance occurring in the root consists chiefly of *pectose*, the same substance which occurs in unripe fruits, and in turnips and carrots; so that it is not a secretion, but a product of conversion of the cellulose of the cell-membranes, of a chemical nature. The milk vessels occurring in the dandelion are amongst the most ramified which occur anywhere in plants, springing from main stems, then ramifying and forming ultimately large reticulated systems around the woody nucleus. On examining into their origin, it appears that their main stems are produced by the amalgamation of the so-called conducting cells which accompany the bundles of milk vessels, and probably constitute the organ for conducting back the juices elaborated in the leaves. This fusion is induced by the conversion into pectose of the membranes of the cells, consisting at first more or less entirely of cellulose.

Some interesting observations have been made by Henrici on the functions of roots in supplying water to the plant, and on the development under certain conditions of special roots destined for this purpose, to explain the frequent occurrence of plants sending roots into wells, cisterns, drain-pipes, &c., where they exist in continual contact with a body of water. In drain-pipes the roots of plants usually considered to be free from aquatic tendencies, such as rape (brassica), sometimes accumulate to a surprising extent. Henrici surmised that the roots which most cultivated plants send down deep into the soil, even when the soil is by no means porous or inviting, are designed especially to bring up water from the subsoil for the use of the plant. He devised an experiment for the purpose of establishing the truth of these views, by planting a young raspberry in a funnel filled with garden soil, the neck of the funnel dipping into water from which it was separated by a paper filter. Roots penetrated the soil and the filter, and became *water-roots*, which being ultimately cut away, and the plant put into soil and placed in a conservatory it grew vigorously. Henrici considers that he has proved that plants extend a portion of their roots into the subsoil, chiefly for the purpose of gathering supplies of water.

III. CHEMISTRY.

Chemical science has made steady progress during the past quarter. Not only do the proceedings of the various learned societies chronicled in these pages, the Royal, Chemical, and Royal Institution, show that our chief workers have not been idle, but the records of progress which we are about to give, are also evidence of important advancements which find their way to the public through other channels than the leading societies.

Deserving perhaps the foremost place, stand the researches of Professor Graham, Master of the Mint, on the Molecular Mobility of Gases. The researches of this philosopher on liquid diffusion must be fresh in the memory of every chemist, resulting as they did in the introduction of a new and most valuable means of analysis into the laboratory. The present investigations* prove that the same laws which he has already shown to apply to liquids in their passage through porous diaphragms, likewise influence gaseous bodies. In researches of this character the difficulty has been to find a porous body whose structure was sufficiently compact to prevent the passage of the gas *en masse*, but yet to permit its molecules to have free movement. Thin plates of compressed black-lead have at last been found to possess the desired property, and by employing this material as the porous septum in the diffusiometer several remarkable results have been obtained. Space will not permit us to give even a brief abstract of the whole of this important paper, we will, therefore, content ourselves with drawing attention to one or two of the most striking results. The separation of the gases of the atmosphere by transmission through a porous material has a peculiar interest, although from the nearness of the densities of oxygen and

* 'Philosophical Transactions,' part ii. 1863; and 'Philosophical Magazine,' xxvi. 409.

nitrogen no great separation can be effected by this method; the diffusive velocity of two gases being inversely as the square roots of their densities, nitrogen exceeds oxygen in activity by about 6·7 per cent. By experiment, about three-fourths of the theoretical separation was actually obtained, and other experiments were then instituted, with a view of ascertaining what would be the effect of other porous bodies, such as stucco, or earthenware, on atmospheric gases, and the result shows that all porous masses, however loose their texture, will have some effect in separating mixed gases, moving through them under pressure. The air entering a room by percolation through a wall of brick, or a coat of plaster, will thus become richer in nitrogen, in a certain small measure, than the external atmosphere. Where such a small difference of specific gravities exists the separation of gases is a severe trial to the powers of the atmolyser, but with greater disparities of density the separation may become very considerable. When an explosive mixture of one volume of oxygen and two volumes of hydrogen are transmitted, the result is very striking, the hydrogen diminishes from 66·66 to 9·3 per cent., and the gas ceases to be explosive, a lighted taper burning in it as in pure oxygen. In other experiments on the diffusion of carbonic acid into air, the remarkable result was discovered that in perfectly still air its molecules spontaneously alter their position, and move to a distance of half a metre in any direction in the course of five or six minutes, whilst the molecules of hydrogen disperse themselves to the distance of a third of a metre in a single minute. The Professor considers that such a molecular movement may become an agency of considerable power in distributing heat throughout the atmosphere.

The new element Cæsium has been the subject of further investigation by Bunsen;* he separates it from Rubidium by converting the two metals into tartrates, and adding a sufficient excess of tartaric acid to convert the rubidium into bi-tartrate whilst the cæsium salt remains neutral. The mixture is then exposed in a funnel to an atmosphere saturated with moisture, when the neutral cæsium salt deliquesces and runs through, while the acid rubidium salt remains behind. Bunsen has deduced, from cæsium compounds so purified, the equivalent 132·99; whilst Johnson and Allen, working with very much larger quantities of material than Bunsen was able to obtain, deduced the number 133·03. These fully authorize the use of the round number 133 as expressing the combining proportion of this element.

The very rare metal Vanadium is likely to be somewhat more available for scientific research, if not for practical applications, now that Riley † has found it to occur in the Wiltshire oolitic iron ore and in the pig-iron smelted from it. He finds that this pig-iron will readily furnish any quantity of vanadium with tolerable facility; it appears to contain more vanadium than that made from the Taberg

* Poggendorf's 'Annalen,' cxix. 1.

† 'Journal of the Chemical Society,' New Series, ii. 21.

ore in Sweden, and it is supposed that this is the first time that this metal has been found in English pig-iron.

A note on the Quantitative Determination of Sulphur by Dr. D. S. Price,* deserves notice, as it draws attention to a source of error which is very liable to be overlooked by analysts. He finds that the ordinary method of estimating sulphur, by fusion with nitre over gas, is liable to error in consequence of the coal gas giving sulphur to the contents of the crucible. Experiments show that nitre, which before fusion was free from sulphur, contained an appreciable quantity after exposure to a gas flame for three quarters of an hour.

Perhaps one of the most important problems in analytical chemistry is to obtain the reagents of that exceptional purity which is absolutely necessary in many researches. In toxicological inquiries it is, of course, of vital importance that the sulphuric acid should be free from that very common impurity arsenic, and chemists will on this account be glad to know of a method by which this difficult problemn can be solved. The method of distillation as ordinarily practised is of no value, but it may be made available with the modifications introduced by MM. Bussy and Buigne.† These chemists have shown that when the arsenic exists in the state of arsenious acid it distils over, but when it is present as arsenic acid the whole remains behind in the retort. Upon boiling the suspected acid with a little nitric acid, or, as Maxwell Lyte proposes,‡ by adding a little bichromate of potash and then distilling, the product will be perfectly free from arsenic.

A new pigment, which appears likely to afford a ready means of preserving iron and other metals, has recently been introduced in Paris by M. Oudry, of the Auteuil electro-metallurgic works. Pure copper is first precipitated by the galvanic process, and it is then reduced to an impalpable powder. This powder is then mixed with a preparation of spirit and used as ordinary paint. The articles coated in this way have all the appearance of electro-bronze, while the cost is less than one-sixth; it is likely to last from eight to ten years, and beautiful effects are produced by means of a dressing of acidified solutions and pure copper powder.

A patent has recently been entered by M. Clavel for modifying the beautiful blue dyes obtained from coal tar, so as to render them soluble in water. He dissolves the dye in fuming sulphuric acid and then dilutes the solution considerably, passing steam in at the same time. The colouring matter is then precipitated in flocculi by the addition of common salt; upon washing the salt out, the dye remains perfectly soluble in water. Whilst speaking of these aniline dyes we may mention with pleasure that the parent to whom they all owe their origin, Dr. Hofmann, has been honoured by the Jecker Prize of 5,000 francs, given by the Paris Academy of Sciences, for his researches on artificial organic alkalies.

* 'Chemical News,' viii. 285.
† 'Journal de Pharmacie et de Chimie,' xliv. 177.
‡ 'Chemical News,' ix. 98.

In these days of falsification it may be of some interest to give a simple test for artificially-coloured wines, which we owe to Blume. He saturates a piece of bread crumb with the wine to be tested and places it in a plate full of water. If the wine is artificially coloured, the water very soon becomes reddish violet, but if the colouring matter is natural, the water, after a quarter or half an hour, is but very little coloured, and a slight opalescence only is perceptible.

From its ready liberation of sulphurous acid, hyposulphite of soda is likely to become a valuable bleaching agent; M. Artus has applied it very successfully to the bleaching of sponges. He first washes them in a weak solution of caustic soda, and then, after thorough rinsing with water, transfers them to a weak mixture of hyposulphite of soda and dilute hydrochloric acid. In a short time the sponges become nearly white, without having their valuable qualities injured in the least; they are then to be taken out and well washed.

The Calabar bean has been well investigated physiologically in this country, but the alkaloid, to which it owes its wonderful property of contracting the pupil of the eye, has only very recently been isolated by MM. Jobst and Hesse;* they have given it the name of Phytostigmine, and as yet have only found it in the cotyledon. It is a brownish-yellow amorphous mass, easily soluble in ether, alcohol, and benzol, and slightly soluble in cold water. Its aqueous solution has a decidedly alkaline reaction. It produces very strong contraction of the pupil, and one curious fact observed, is that the poison produces contraction of the pupil when applied to recently-dead animals. Now that Calabar bean is so extensively used by ophthalmic surgeons, the isolation of its active principle cannot fail to be of value.

Poison bottles and poison corks, poison caps and poison stoppers, have all successively been tried, with the object of preventing careless or sleepy nurses from giving medicines out of the wrong bottles and thereby poisoning their patients; but they are all open to the objection that when the liquid for which they have been originally used is exhausted, the very nice-looking bottle is generally replenished with eau de cologne, tincture of senna, or such-like innocent compounds, and the object of having a peculiarly-contrived bottle is thereby defeated. Perhaps the most unobjectionable of all these attempts to substitute a mechanical contrivance for ordinary caution and common sense, has been recently brought forward by Mr. Thonger before the Pharmaceutical Society. It consists of a patent label having a border of sand-paper round it, thus appealing strongly to the sense of touch, which it is presumed will warn the holder that danger is near. These labels are applicable to dispensing bottles and to the smallest phials, and possess an advantage over any other contrivance, as they can be stuck on any vessel, and as readily removed when the poisonous contents are done with and the bottle is required for something else.

The Society of Medical Sciences of Brussels some time ago offered a prize for the discovery of a substitute for the Cinchona alkaloids.

* 'Annalen der Chem. und Pharm.' cxxix. 115.

The silver medal has recently been awarded to Dr. Leriche for his memoir on the Employment of Tannin as a substitute for Cinchona. He arrives at the conclusion that pure tannic acid is an excellent antiperiodic, and possesses real efficacy in the treatment of all intermittent fevers of a simple quotidian type. Now that we are threatened by some alarmists with a Quinine famine, the discovery of anything which can be used to supplement, or replace, this invaluable drug is of the very highest importance.

IV. GEOLOGY AND PALÆONTOLOGY.

The past quarter has not been unmarked by some important attempts at progress, and amongst these Professor Frankland's effort to evolve a Meteorological theory for the causation of the Glacial era will, whether accepted by geologists or not, rank as one of the best towards a solution of this recent and remarkable geological period. But as in mathematical demonstrations everything depends on the basis taken, so in that excellent chemist's hypothesis the correctness of his conclusions is dependent upon the establishment of the assumptions upon which his hypothesis is built—namely, on the actual existence of an internal molten core within our earth, and the gradual cooling down of our planet from an original incandescent state. The argument Dr. Frankland holds is, that the formation of glaciers is a true process of distillation, requiring heat as much as cold for its due performance. The produce of a still would be diminished, not increased, by an absolute reduction of temperature, and it is a wider differentiation of temperature that is required to stimulate its operation into fuller activity. The great natural Glacial apparatus is divisible into three parts—the evaporator, the condenser, and the receiver. The ocean supplies the vapour, the mountains are the ice-bearers or receivers, but the dry air of the upper region of the atmosphere, which permits the free radiation into space of the heat from aqueous vapour, is the true condenser. The sole cause of the phenomena of the Glacial period, then, Professor Frankland believes, was a higher temperature of the ocean than obtains at present, and the greater differentiation brought about by the difference of the rates of cooling of the water of the sea and of the rock-masses of the terrestrial crust. According to his notions, all the waters of the ocean primarily existed in the atmosphere as vapour, and with the gradual cooling of the earth they were first allowed to be deposited upon it in a thermal liquid state, and subsequently these ocean-waters have been gradually reduced to their present temperature—the glacial phenomena occurring during the later stages of this cooling operation. Those effects were brought about chiefly by two causes—the high specific heat of water compared with granite and other rocks, and the comparative facility with which radiant heat escapes from such rocks through *moist* air. The amounts of heat associated with equal weights of water and granite are as 5 to 1, or, if equal volumes be taken, water requires to lose twice as much heat as granite in order to cool through the same number of degrees. But in regard to the escape of radiant-heat through moist air, there is a high degree of difference between them. It seems that radiant heat will not pass from a given substance through the vapour of that substance so rapidly as it will through dry air or a vaporous medium of any other substance; and just as the vapour of sodium cuts off the light rays of sodium in the spectrum, so the vapour of water seemingly, to a great extent at least, arrests the radiant-heat rays emanating from water; and thus, while there is free radiation from the snow-capped mountains into the dry regions of the upper air, the radiation of heat from the sea is blocked by the "blanket" of aqueous vapour which rests over its surface. Whilst then the ocean in the Glacial era retained a temperature considerably higher than at present, Dr. Frankland considers the mountains or ice-bearers had undergone considerably greater refrigeration; and thus whilst the evaporation of the ocean, receiving heat through its earth-floor from the internal molten core of our planet, was in much greater volume than now, the mountains were not very different from their present state, and were efficient ice-bearers for the vapours condensed in the upper atmosphere, and falling upon them as snow, which, accumulating in vast quantities, would not only reduce the level of the perpetual snow-line, but refrigerate also climatal conditions. Not content with this earth alone, Professor Frankland attempted, though not very successfully, to apply his Glacial hypotheses to the moon, seeking there for traces of glacial action. Assuming the solid mass of the moon to have contracted in cooling at the same rate as granite, its refrigeration, though only 180° Fahr., would, he calculates, create a cellular space within its crust of upwards of 14 millions of cubic miles, or more than sufficient to engulf the whole of the lunar oceans, if any proportionate to the seas of our own earth ever existed there. His final conclusions are, that a liquid aqueous ocean can only exist on a planet so long as the latter retains a high internal temperature, and that the moon becomes in this respect a prophetic picture of the ultimate fate of our earth, "when, deprived of external seas and all but an annual rotation on its axis, it shall revolve round the sun an arid and a lifeless wilderness." The hypothesis is clever, and contains germs of philosophy and truth, but we doubt if geologists generally will accept it, at least in its totality.

Although the internal-heat and gradually-cooling doctrines are pretty generally accepted as theories, and not as still unproven hypotheses, these topics, with the Glacial period and the causes of earthquakes, still seem productive of a kind of geological nightmare, which disturbs and terrifies not a few reflective intellects. The Rev. Professor Haughton has introduced some of them into an able paper before the Geological Society of Dublin—"An attempt to calculate the Duration of Time involved in Geological Epochs." Commenting on the vagueness of idea involved in the "long periods of time" habitually spoken of, he undertook, as a point of interest, to estimate, upon the basis of a gradual cooling down of our globe, for how long a time it has been possible for animals to have existed on it. For this estimate the basis selected was Helmholtz's deduction from the experiments on the cooling of basalt by Professor Bischoff of Bonn—that if the whole globe were constituted of that rock, it would take 350 millions of years to cool from 2,000° to 200° Centigrade. If the earth, then, has cooled down from a gaseous condition to its present consistence, it is evident animals could not have existed on it before it acquired solidity. Even after this it is difficult to believe in the general existence of life at temperatures above that at which albumen, the chief ingredient of flesh, coagulates. The Professor therefore takes a range from this point, 122° Fahr. to 77° Fahr. the temperature which has been suggested for our island in the London-Clay period, and sufficiently near to Professor Heer's estimate from the evidence of fossil plants of 72° for Switzerland in the Miocene age to acquire credibility. Upon these data, Professor Haughton concludes that the earth, if of basalt, would have required 1,280 millions of years to become cooled through the required space since animal-life was possible on our planet.

Not less important, although to some extent going over old ground, is the admirable analysis M. Paul Gervais has made of the evidence of the osseous caverns of Languedoc in respect to the antiquity of man. Much, indeed most, of this evidence has been long before the world, but the treatment it has now received is more scrutinizing and resultful than any hitherto accorded to it. The first documents on this subject are those of M. Tournal, who in 1827 noticed the association of the bones of man with those of extinct species of animals in the caverns of Bize. Two years after, M. Christol published his notice of other fossil human bones from the cavern of Pondres, examined by himself and M. Dumas. Cuvier did not ignore the principal facts thus brought forward, but he never regarded them as sufficient to cause him to change his preconceived opinion, and he objected to them that they were merely cavern-remains, and not found in regular beds, such as those which contain the bones of elephants, rhinoceroses, the great bears, lions and hyænas; the eminent naturalist's notion being that in caverns the relics of various ages were liable to intermixture from natural causes, as well as accidents, and that the objects in contiguous positions might therefore be of very different dates. M. Gervais now takes the fullest evidence he can get of the caves of Bize and Pondres, and to the consideration of them adds new facts obtained from those of Roque and Pontil. The cavern of Bize is chiefly known through the long memoir of M. Marcel de Serres, who records, besides many species still found in the district, an extinct antelope, *A. Christolii*, and four kinds of deer equally annihilated and distinct from any described species—the *Cervus Destremii*, *C. Reboulii*, *C. Leufroyi*, and *C. Tournalii*. The Aurochs is also cited, although it is more likely the remains were those of *Bos primigenius*. The humerus attributed to the Arctic bear is probably that of the ordinary bear of the European mountains, as M. Gervais has obtained fragments of the latter from Tour-de-Farges and Alais. The *Antelope Christolii* did not differ greatly from the chamois. Two portions of the canons of a chamois in M. Gervais' possession consist of only the digital ends and a very short portion of the diaphysis, from which he concludes that these bones were violently broken, and by the act of man—the long bones cracked by the primitive men for the sake of their marrow being distinguishable from those crushed by animals, even when they occur together in the same deposit. M. Gervais has also a digital extremity of the posterior canon and other similar fragments of the long bones of *Bos primigenius* separated from their middle portions by violent fracture, evidently accomplished by the hand of man. By referring to M. de Serres' plates in conjunction with specimens recently obtained, this able palæontologist concludes that the majority of the extinct deer referred to belong to the Reindeer, and remarks that they exhibit this distinctive feature, that the long bones, instead of being entire, as they are in such caverns as those of Brengues which were not inhabited by man, have at Bize been broken; so that if the men of the Cave period had not domesticated these animals, they at least made use of their carcases. It may not be superfluous to add that this cavern contains the débris of primitive pottery, flint-knives, and implements set in deer's horn and in bone. The cavern of Pondres also contains diluvian animals —*Rhinoceros tichorhinus*, ox, cave-bear, *Felis spelæa*, and hyæna, and has often been quoted in support of the high antiquity of man in Europe, remains of his skeleton, his flint knives, and coarse pottery or charcoal having been found in it. These, according to M. Gervais, are mixed pell-mell with the remains of the extinct animals, whence he questions whether there has not been some amount of intermingling. All that he can positively assure himself of is, that the bones of the large animals have not been broken like those met with in caverns which have served as habitations for the primitive inhabitants of our globe, and he consequently doubts the conclusions of MM. Christol and Dumas as to the contemporaneity, in this instance, of the relics of the fossil mammals and those of man with whom they are associated. In respect to Lunel-Viel, M. Gervais thinks it can scarcely be cited in favour of the contemporaneity of man with the extinct diluvian species, as, notwithstanding the restricted extent of the caves in which the human bones have been found, no traces of its inhabitation by man, nor any relics of works, have been brought to light. He considers, therefore, that this cavern belongs to the class of those which M. Steenstrup regards as entirely filled before the agency of man; and he is the more inclined to this opinion, as the animal-bones are not broken by human methods, but are merely crunched by the teeth of carnivora, especially hyænas. He asks, hence, whether, as a general rule, we may not conclude, when the marrow-bones of the food-beasts are intact, that the comminglings of the human with the animal-remains have not been due to the subsequent intervention of floods, burials, or various other upstirrings of the deposits in which such comminglings occur—an opinion confirmed by the following facts from the cavern of Pontil:—Some years since, M. Gervais found there numerous bones of extinct species, as at Lunel-Viel and Pondres, also human bones and some industrial relics; the former belonging to a primitive epoch, and the last, more recent, had also been shown to him as coming from the same cavern. At that time he abstained from speaking of them, not having sufficiently reliable particulars. Now, however, he is better qualified to do so. M. Chausse, Conducteur of Ponts et Chaussées, has made excavations at Pontil, and forwarded to M. Gervais the greater part of the objects of human origin found there, with particulars of their bedding and mode of preservation compared with those of the extinct animals embedded with the rhinoceros. The great extinct beasts, including the *Bos primigenius*, are thus shown to be in a lower bed than those deposits which have yielded the bones of horse, human débris, and the remains of ancient fires, a flint-knife and various instruments made of deer's horn and bone exactly like those of the first period of the Swiss Lake dwellings and met with in the Kjokkenmöddens of Denmark. Moreover, with these was obtained an upper maxillary of a young *Bos primigenius*, corresponding to one of like age from Lunel-Viel, with which it was compared. In the same cavern in the uppermost sediments, were the tusks of the wild boar, and axes of polished stone, such as are considered to be characteristic of the Second Stone Age; and further manufactured objects indicative of the Age of Bronze, have also been obtained. The cavern of Roque was discovered by Boutin, and the bones from thence were some years since shown to M. Gervais, who then requested search to be made for worked flints, of which, indeed, a considerable quantity has subsequently been found associated with human remains. M. Gervais has also secured a metatarsal of the cave-bear. The broken bones in this cavern belong to deer, common ox, and to an animal indicated by M. Boutin in his notice as a goat, of which we may form some conception by supposing it to have exceeded the dimensions of living goats as much as the *Bos primigenius* exceeded living oxen. M. Gervais provisionally names it the *Capra primigenia*. M. Gervais' conclusions from the above facts are, that the first appearance of man in the districts of the caverns of Bize, Saint-Pons, Pondres, and La Roque, although they must be assigned to a period prior to the records of history, cannot yet be admitted to have been, in this region at least, contemporaneous with the existence of those extinct animals to which Cuvier made allusion when thirty years ago he repelled the statements of Tournal, Christol, and Marcel de Serres as to the simultaneous entombment of men and the extinct mammalia in these caverns. The importance of the distinctions marking the particular faunas which have disappeared, and the chronology of these extinctions become, under such reasonings, topics exceedingly evident, and their value in attempts at determining the contemporaneousness of the human remains and relics with the other objects with which they are found must not hereafter be overlooked.

In the Colonies the study of Geology has of late years gained many active students, and we are glad to find in the 'Transactions of the Nova Scotian Institute,' only very recently established, Geological papers of considerable merit. Mr. Belt's remarks on some recent movements of the earth's surface have a tone of interest for us we could scarcely have expected, and refer much to the mother-country and its continental offshoot—the vast island of the Pacific Ocean. The subjects that formed the basis of his paper are chiefly the raised beaches on the shores of the British Channel, described by Mr. Godwin-

Austen, in the 'Quarterly Journal of the Geological Society,' and the rise of land in Australia. It is easy to understand how corals could build up in the course of time great masses of limestone, the difficulty is to account for the breaking up of ancient sea-bottoms, and their upheaval above the level of the ocean-surface. Now, of Australia, it has been known for several years that the whole coast is slowly but surely rising; and in the southern part, the railway between Adelaide and the port is said to have risen 4 inches in 12 months. This elevation is participated in by all the neighbouring islands; at Green Island in Bass's Strait, and in Tasmania, there are old sea-beaches 100 feet above high water. And one of the most remarkable and suggestive facts in this recent elevation is, that the movement, without tremblings, quakings, or shocks, is so rapid that bones of animals, and pottery thrown out of the first emigrant ships, mixed with shingle and sea-shells, are raised above the reach of the tide. This uprising has progressed to the extent of 300 feet since the present mollusca inhabited the coast. In New Zealand, too, the land is being jerked up as it is on the western coast of America. From these topics Mr. Belt goes to the superficial deposits of sand, gravel, and clay, that are spread over the greater part of Great Britain; the evidence afforded by which seems to indicate in some places upheavals, in others depressions. Convinced that some general law must govern these movements, Mr. Belt has collected and collated, from various sources, sections of deposits from different parts of England and Scotland; and to render the movements more intelligible, has depicted them by means of curved lines, in a similar manner to those used by meteorologists to indicate the fluctuations of the barometer. Movements of the earth's surface are in this way depicted from examples taken from the most southern part of England, and from the other extremity of the island, 350 miles apart, and for the purpose of showing how general these movements have been another diagram is given of the changes of level in Nova Scotia in recent geological times, and another of a portion of North America, when the land stood, at one time at least, 500 feet higher than it does now. These few widely-separated examples are sufficient to prove what was well known before, the general instability of the earth's crust, but the diagrammatic method of showing these elevations is very suggestive of the utility of symbolizing earth-movements in this way for comparison.

The western coast of the Peloponnesus is a region little known to geologists, and every detail from thence is consequently valuable. We are glad, therefore, to see that an interesting sketch by Dr. Weiss, the Professor of the University of Lemberg, in Gallicia, of a journey made by him in that district, has been laid before the Imperial Institute of Vienna. He notices many very productive localities for Tertiary fossils, which, by a proper exploration, he thinks would lead to very interesting results – although the fossils are abundant, the Doctor, in consequence of the wretched social condition of the country, made but a scanty collection, and is unable to give even an approximately full account of its physical aspect. From the town of Zante the view extends over the Bay of Gastuni to Katakolo, the highest point of which is marked by the walls of Pondiko-Kastron. Towards Arcadia the coast flattens, and opens an uninterrupted panorama of the hill-plateau of the Morea, terminating on the north in the peaks of the Cyllenic mountains, and on the south by the rocky portions of the Taygetos. The Cape consists of a coarse-grained marine limestone, of Upper Pliocene age, in many places exhibiting the old borings of molluscs, and overlaid by deposits of sand and marl, which cover the undulating ground for miles along the sea-shore, and up to the base of the mountains in the interior. The stone-marl around Pyrgos abounds in *Ostrea lamellosa*, and in the limestone and sandstone are species of *Cardita*, with *Cardium edule*, *Turritella communis*, *Venus multilamella*, and *Scalaria pseudoscalaris*. Pyrgos itself stands on a colossal oyster-bank, portions of which are exposed to the eye in many parts of the town. It is overlaid by a thick stratum of marl, in which but very few fossil remains are to be found. Dr. Weiss's sketch is principally a description of the routes taken, and will be a useful guide to future explorers of this unworked region.

Dr. Carte has recorded the discovery of bones of the Polar bear in Lough Gur, county Limerick. In the paper before the Dublin Geological Society, in which he has described them, he comments on the extreme abruptness with which, in the newer formations, mammalian forms have appeared in abundance, contrasting in this respect with the gradual appearance of the lower forms of life in the older strata.

The second part of the excellent monograph of Rissoidea, by MM. Gustav Schwartz and Mohrenstern, of Vienna, contains the genus Rissoa, illustrated by four fine lithographic plates. The author gives in a diagrammatic form the relationships of the recent and fossil species, referring the 30 recent species to 11 items in the Pleistocene age, these again to 6 in the Pliocene, these to 4 in the Miocene, 2 in the Oligocene, and finally to one derivative, the *Rissoa nana* in the Eocene.

Mr. S. V. Wood, jun., has published an admirable article on the Red Crag and its relation to the Fluvio-marine Crag, and the Drift of the Eastern Counties. From the result of his survey he comes to the conclusion, that in the Red Crag, once regarded as of Miocene age, we have the initiatory stage in England of that series of events which, known under the term "Drift," began by the encroachment upon the land of England of a bay of the Northern Ocean, and which encroachment afterwards extended over the area of the Eastern Counties, and ultimately involved the submergence of that still more extensive area now covered with the ice-borne detritus and clay of the northern Drift.

There is often more information to be got from, as there is certainly less trouble in reading, a pamphlet of a single sheet. In England we have had Professor Ramsay strenuously contesting for the ice-scooped origin of the Swiss lakes, and the eloquent Ruskin as enthusiastically defending the powers of weather and water upon, and the effects of molecular motion within, the rocks. The learned professor of Berne, M. Studer, now appears before the world in a *brochure* of 16 pages, which he opens with the admission, that "in the origin of the Swiss Lakes we have a problem difficult to resolve," and of which it is hard to assign precisely the date in the series of geological events. On the one hand we have Buch, Hoffman, and Ball, fully persuaded that the same causes which elevated the Swiss mountains produced the depressions which separate them. They think that the elevation was accompanied by *crevasses* more or less profound, which have formed the valleys, and that in the interior there exist other cavities, the roofs of which will be subsequently broken in—the present lakes being the remains of such cavities or founderings which have not yet been filled up by the silt brought down by the rivers. On the other hand, the disciples of Buffon, Playfair, and the Werner school, attribute the valleys and water-basins to erosion, or the destructive action of fluids in motion. The latter class, as we have already noticed, are split into two parties, and disagree as to the nature of the erosive medium—the one following their ancient masters, look to the currents of the sea, rivers, and torrents; the others, amongst whom are some of our own, and French and continental geologists, advocate the newer theory of their having been scooped out by the grinding action of massive glaciers. Each of these theories may be justified by particular facts; and M. Desor, at least, adopts them both, and applies either one or the other, as circumstances demand, distinguishing the lakes as orographic, and lakes of erosion. The former may be further divided into three classes—the lakes in synclinal valleys, such as the lake of Bourget; those in isoclinal, such as Brienz and Wallenstadt, and those in the transverse valleys or *cluses*, of which the lakes of Thoune and of Uri are examples. The lakes of the Alps, according to M. Desor, are chiefly orographic; whilst those of Neuchâtel, Bienne, Morat, Zurich, Constance, and others in Lower Switzerland, are lakes of erosion. The question of the epoch of their formation is, however, very much complicated when the strata around them are examined. All over Lower Switzerland and the Jura are spread the well-known "Alpine blocks," which by their mode of transport would necessarily have passed above the lakes in arriving at their actual sites from their original beds; and we cannot conceive why, if a current brought them, it should not have filled their basins and made a great mound of débris at the débouchures of the Alpine valleys. This difficulty involving the impossibility of the suspension of such blocks in mid-air, or the unlikelihood of their sustention on the surface of water 1,000 feet above the valley below, has been one of the main causes of the readiness with which the hypothesis of the former greater extension of the glaciers has been received, for across the surfaces of the ice-filled depressions the Alpine blocks would have naturally travelled from the Alps to the Jura. This general body of ice, covering all the valleys and deep hollows, is certainly a cause of uncertainty as to the epoch of the formation of the lakes, for they may evidently be anterior to the glacial epoch, their basins during that era being filled with water or ice; or they may be posterior, although M. Studer is not disposed to admit a posterior origin, which appears too recent to reconcile with the evident connection of the basins and valleys with the orography of the country.

Another difficulty occurs. For a long time there has been known to exist below the boulder-drift a *terrain erratique,* a deposit of sand and clay horizontally stratified, and possessing all the characters of a river deposit—the *terrain du transport* of Elie de Beaumont, or the *alluvion ancienne* of Necker, the *diluvium* of recent authors—in the gravels of which the constituent rocks of the pebbles are found to be derived from the Alps or the sub-Alpine hills, whilst the boulder-blocks themselves also present different characters, according to the nature of the different valleys through which they have been carried, and corresponding to the rocks *in situ* in such valleys and their tributaries. It is evident, as M. Studer remarks, that the presence of this ancient alluvium throws us again into all those difficulties from which we thought ourselves freed by the hypothesis of the former greater extent of the glaciers. The difficulty, he thinks, may perhaps be diminished by reducing as much as possible the *mass* of those gravels, the transport of which across the lakes, before the great extension of the glaciers took place, seems incontestable ; and that, as these horizontal beds of ancient alluvium repose upon the denuded or sliced-off edges of the inclined beds of molasse, the date of their formation is necessarily placed between the catastrophe which elevated the Tertiary beds and the epoch of the great extension of the glaciers. After a careful analytical survey of the physical and geological aspects of the lake-country, M. Studer comes to the conclusion of the insufficiency of erosion in accounting for the origin of the valleys and lakes of the Alps ; and he considers there is no alternative but to recognize with M. Escher an intimate connection between a great number of the Alpine valleys and the inclined positions of the beds of the mountains which separate them. These, then, are true orographic valleys, such as M. Desor has noticed in the Jura, and to the two kinds he has described, the synclinal and isoclinal, there ought to be added for the Alps another—the anticlinal valleys. The *cluses*, he further considers, are evidently fractures enlarged by erosion ; and he adds a fourth class of valleys—those of subsidence. If lava-currents, which often traverse loose sand, do not burrow into the soil in their progress, is his argument, how can glaciers which have less power than even such currents of water as our senses will not detect the motion of, and which even at this slow rate move over an under-plane of water and ground-adherent ice, effect such enormous erosion as is involved in these lake-basins? He looks, therefore, to subsidences as their chief cause. In this case the ancient alluvium at the bottom of the basins involves the supposition of the lapse of a considerable period of time between the disturbance and the filling up of the depths of the *crevasse ;* and as a proof of the occurrence of such an interval, he refers to the great difference between the faunas and floras of the last or newest beds of the molasse, and the first or oldest of those of the alluvium, urging how great a length of time it would require to produce such differences of climatal conditions as to enable a fauna such as that of the Confederate States to supplant the present fauna of Europe—a difference which is not greater, however, than that between the animals of the Molasse age and the elephants, oxen, and deer of the Diluvium.

V. MINING, MINERALOGY, AND METALLURGY.

The most noteworthy fact in connection with British mining which has presented itself during the quarter, has been the production of gold from the quartz lodes of the Cambrian Hills. Many years have passed away since we were told that gold was to be found in Merionethshire. Some of the precious metal was exhibited in 1851, but this had been obtained at a cost which far exceeded its value. In 1861 the Vigra and Clogau mine gave 2,784 standard ounces of gold to the adventurers, but in 1862 they obtained 5,299 ounces. For some time the prospects were dull; large quantities of quartz were worked containing no visible gold, and an infinitesimally small proportion was separated by amalgamation. However, the prospects brightened towards the close of the year 1863; and during the past quarter the following quantities have been duly reported:—

	Oz.	Dwts.		Cwt.	Qrs.	lbs.	
1.	103	11	from	7	1	23	of quartz.
2.	185	16	,,	8	1	14	,,
3.	296	16	,,	10	3	0	,,
	586	3		26	2	9	

This is perhaps the most extraordinary yield on record of gold from a quartz vein. We find, however, by the report of the Vigra and Clogau Mining Company, that since the date of their last report, 1,059 ounces of gold have been received, this being obtained from quartz giving 24 ounces of gold to the ton on the average.

In the neighbourhood of Bala Lake some discoveries were made last year, from which much was expected. This has not, however, been realized. But in January some quartz was operated on from Castell-carn-Dochan, giving from $5\frac{3}{4}$ ounces to $7\frac{1}{2}$ ounces to the ton. At Penrhos and Tynyrhenrhos, stones have been taken from quartz lodes containing visible gold. The extraordinary products of the Vigra and Clogau mine naturally awaken the hopes of the adventurers in the other gold-mines around Dolgelly. It should, however, be borne in mind by all, that nothing can be more capricious than the occurrence of gold in the quartz lodes. We know not when the gold may disappear—we have no rule to guide us as to its discovery. Therefore, caution should be the rule of all speculators, who are tempted by the auriferous treasures of the Welsh mountains.

British mining presents but little that is worthy of our record. The fact that upwards of 10 tons of nickel and cobalt speiss has been obtained from the sandstone of Alderly Edge, in Cheshire, is of interest.

In our last number we drew especial attention to the coal-cutting machines of the Ardsley Coal Company, and of Ridley and Jones. Mr. Firth, of the former company, informs us that the Ardsley machine has been reduced to two feet in length, "therefore," he says, "in the progress of invention we have gone far beyond the one in question." The

Ardsley machine is being used in several collieries, and the reports are in the highest degree satisfactory.

In connection with this really important subject, a very admirable paper was read at the Institution of Civil Engineers, on February 16, by Mr. Thomas Sopwith, jun., on "The Actual State of the Works on the Mount Cenis Tunnel, and Description of the Machinery Employed."

So much has been said of late respecting this extraordinary undertaking, and of the machinery employed in boring this tunnel, that we need not occupy our pages with any description of either the one or the other. The following brief quotation shows the present rate of progress:—"The tunnel, on 30th June, 1863, had been driven (including the advanced gallery), at Modane, 1092·25 metres, and at Bardonneche, 1450·00 metres. The advancement in June last, at Modane, was at the rate of 4·719 feet per day. At this rate of progress at both ends, the tunnel would be finished in nine years two and a-half months from that time."

The machine employed by M. Sommeiller is very accurately described, and admirably-executed drawings are given in a work by M. Armengaud (aîné).* In the same work will be found a description of a rotating perforator, "perforateur rotatif," of Schwartzkopf and Phillipson. This machine is exceedingly portable, and especially applicable to the conditions which prevail in our metalliferous mines.

Attention has been directed, since the experiments which have been made at Mont Cenis, to the use of boring machinery in the metalliferous mines of this country. A machine, invented by Mr. Crease, but resembling strongly the machine just noticed, has been used in the Vigra and Clogau gold mine, near Dolgelly. The result of the trials made in driving a level, went to show that several improvements were required; consequently it was placed in the hands of Mr. Green, of Aberystwyth, and that gentleman has shown much mechanical ingenuity in adapting new principles to the original idea. The improved, or Green's boring machine, is shown in the accompanying plate. This machine consists of (Figs. 1, 2) an upright pillar of cast-iron, 3, fixed upon a low tram waggon, 1, running upon rails in the level, and having within it, in the upper part, an upright screw, 4, and cross-head; and in the lower part another screw, 2, by means of which the machine can be firmly fixed between the floor and the roof. This pillar is encircled by an iron collar, 5, which can revolve round the pillar, but which can, by means of a rack and pinion, 7, 8, worked by the worm, 6, be raised or lowered upon it. Attached to this collar is an arm with adjustments, 9, 10, 11, 14, which carries the boring machine proper (Fig. 4). At the end of the arm is a cylinder resting upon a screw bed (Fig. 3), 15, in which works an ordinary slide valve. The piston is shown in section in Fig. 4; to it is attached a hollow piston-rod, in which the borer is placed. By the side of the cylinder are

* 'Publication Industrielle des Machines, Outils et Appareils les plus perfectionnés et les plus récents, employés dans les différentes branches de l'industrie française et étrangère.' Par Armengaud (aîné). Paris: MM. A. Morel et C^ie^. See also 'Les Mondes, Revue Hebdomadaire des Sciences,' 21 Jan., 1864.

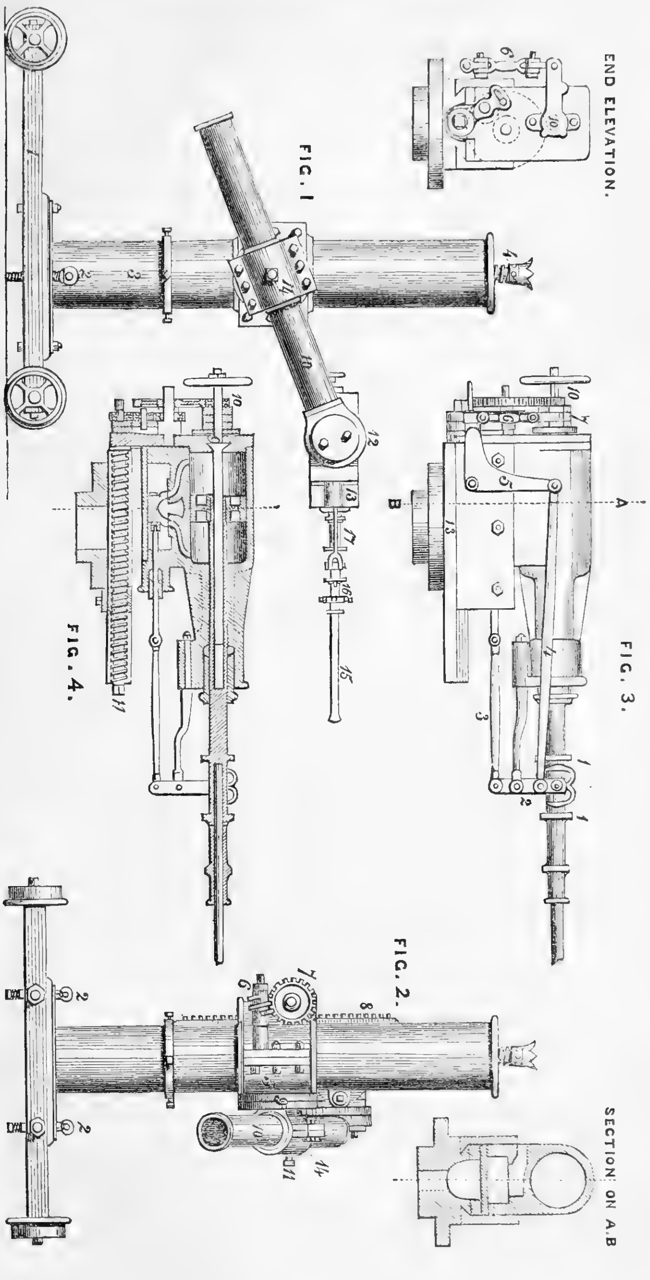


FIG. 1
FIG. 2.
FIG. 3.
FIG. 4.
END ELEVATION.
SECTION ON A.B
A
B

attached the connecting-rods, marked 3, 4; one working the slide valve, the other acting by levers 5 and 6, giving motion to a ratchet-wheel, which, acting on a system of tooth-wheels 10 (see end elevation), cause the piston and borer to make a quarter of a revolution. These levers are worked at each stroke by means of projections on the piston-rod 1·1. The revolutions can also be effected by hand, through the wheel and connection, 9; and this marks the main difference between the machines of Crease and Green—the former having only the means for making the revolution by hand.

At the same time that the borer makes its quarter revolution, the screw 11 is caused by tooth-wheels to make an equal turn, giving a forward motion to the cylinder, and bringing the borer more into the hole.

This machine can be worked by either steam or compressed air, the latter being the most convenient, and at all times to be preferred, especially in driving the badly-ventilated end of long levels.

These notes and the accompanying drawing will show that the borer can be placed in any position with regard to height or direction in a horizontal plane. There is also a joint Fig. 1-12, by which it can be adjusted in any direction in a vertical plane.

We are informed that Mr. Crease's boring machine has been recently introduced in two mines near Tavistock, and we know that experiments are being tried in some of the lead mines of the North of England, and in the copper mines near Camborne, Cornwall. Another boring machine for "driving tunnels, mines, adits, shafts, quarries, &c.," has been constructed and patented by Mr. George Low, of Newark. In its more important features it does not differ materially from that already described. We are informed that Mr. Low's machine has been applied with success by the Connoree Mining Company. The machine can be made with one, or any number of borers, which, on an average, will bore holes at the rate of two inches per minute, as proved by actual trial. We hear of several other machines, some to be worked by air or steam, or by water pressure, and others to be moved by manual labour. The attention which is now being directed to the important question of relieving men from the severe tasks of boring rocks in the confined ends of levels, appears likely to result in the production of some simple and efficacious mechanical arrangements.

The advantages of employing machines of this class are great: economy in working should at once recommend them to the mine proprietor, and on the score of humanity, as removing from living muscle its severest toil, and giving it to unwearing metal, the philanthropist should urge their introduction. Another advantage would be gained by using compressed air machines; the impure air of the levels would be dispelled by the escape of that which we had used to bore our rocks.

In a journal such as ours it is important that we should preserve a record, easily available, of the progress of our special industries, The report of the Registrar-General on the census of 1861 enables us to compile a list of persons who were then connected with our mining operations. From this it appears that 1,012,997 persons are engaged in the great order of workers in minerals. Of these 248,284 are connected with coal pits; 32,041 are tin or copper miners, 18,552 are lead miners, 20,626 iron miners, 7,502 are indefinitely described as miners, 2,502 are described as secretaries and servants of mining companies.

Women are still employed at coal works, chiefly at the pit's mouth, their number being 3,763. We learn also that 142,170 males are employed on stone and slate quarries and in clay works; and 2,120 in the salt works of the kingdom. The workers in the metals we exclude from our notice, since these are too extensive, and they are not, in all cases, sufficiently defined.

With this large number of people employed, and producing, as they do annually, mineral wealth to the value of 30,000,000*l.* sterling, it is astonishing that no effective system of education has taken root in this country, which can be regarded as possessing the requisites of mining schools. There must be some strange prejudices lurking in the popular mind, or this state of things would cease to be.

The English language is poor in technological literature of any kind, and poorest of all in its literature relating to mines, minerals, and metallurgy. This arises from the circumstance that we are a working, and not a writing, people. There are but two weekly journals of any note devoted to mining, these are 'The Mining Journal,' and 'The Colliery Guardian,' and there is one small monthly magazine, 'The Mining and Smelting Magazine.' These are the only representatives of our very important industries. If anyone inquires for a work on British Mining, we are compelled to confess that there is no such book in the English language.

In the German and the French languages there are many periodicals devoted to mines and metallurgy, and to these we must be indebted for much of our information. The best papers indeed, on several metalliferous mining processes, as carried forward in this country, are those of M. Moisenet, which were published in the 'Annales des Mines.'* Many valuable papers on our mines and mining machinery, and many of the highest character on the manufacture of iron, are to be found in the 'Revue Universelle des Mines, &c.'† It is not a pleasant thing to acknowledge our poverty, but it is satisfactory to know that our several industries are of sufficient importance to demand the attention of such journalists as those who conduct the two works which we have named. In the 'Revue Universelle' occurs an admirable paper by M. S. Jordan, on the mines and metallurgical industries of France. From this we learn that the consumption of coal in France amounts to 15,300,000 tons, while the production is only 9,400,000 tons, yet this is an

* 'Annales des Mines; ou Recueil de Mémoires sur l'Exploitation des Mines, et sur les Sciences et les Arts qui s'y rapportent.' Paris: Dunod

† 'Revue Universelle des Mines, de la Métallurgie, des Travaux publics, des Sciences et des Arts appliqués à l'Industrie.' Sous la Direction de M. Ch. De Cuyper. Paris et Liège: Noblet et Baudry.

increase of 4,500,000 tons in the last ten years. The production of pig-iron in 1862 was 1,053,000 tons, which was double the quantity made in France six years previously. Our space will not allow of our quoting from the papers by A. Burat, E. Bède, and others on the special subjects which belong to this division of our Chronicle. We cannot, however, refrain from directing our mining engineers to a "Note sur quelques perfectionnements introduits dans l'exploitation des Mines," par Jules Havrez, which appears in the August part of the 'Revue Universelle.' It appears to us to offer many valuable suggestions, by which they might profit. The "Etudes sur l'Acier," by M. de Cizancout, in the 'Annales des Mines,' is a communication deserving the attention of our metallurgists. Professor Rivot has an instructive memoir on the 'Veins of Argentiferous Galena' of Vialas (Lozère). To our miners this paper should be a model, upon which they might build a record of their own experiences.

In the report recently published of the progress of the geological survey of Canada, under the direction of Sir William Logan, there is much matter of especial mineralogical interest. The chapters devoted to the consideration of "mineral species" may be consulted with advantage. They make us acquainted with several modified conditions of known minerals, and with a few which appear to be new varieties. Amongst the metallic minerals which have been discovered in such quantities as to give them a commercial value we find nickel and cobalt, chromic iron, iron ores in considerable variety, copper, lead, silver, and gold. The magnetic oxide of iron has been found in great abundance, this valuable mineral giving 72·4 parts of iron, and 27·6 parts of oxygen. A satisfactory description of the lead and copper mines of Canada is given by the Geological Surveyors. It would, however, have been interesting and important if the present rate of production had been ascertained. As Canada is destined to become a great mineral-producing country, the progress of its economic geology would have formed a very appropriate *addendum* to the report on its scientific geology.*

Gold occurs in this colony, both in veins and in the drift. Some idea of the value of the auriferous deposits may be formed from the following quotation:—"It has been shown that the washing of the ground over an area of one acre, and with an average depth of two feet, equal to 87,120 cubic feet, gave in round numbers about 5,000 pennyweights of gold, or $1\frac{38}{100}$ grains to the cubic foot, which is equal to $1\frac{3}{4}$ grain of gold to the bushel." Several other minerals useful in the arts and manufactures are succinctly noticed, and the occurrence of plumbago especially described, this mineral occurring in a state of considerable purity.

A very interesting description of the production of the bitumens, especially of the petroleum of Gaspé, is, at the present time, important.

* 'Geological Survey of Canada. Report of Progress from its Commencement to 1863, illustrated by 498 Woodcuts in the Text, and accompanied by an Atlas of Maps and Sections.' Officers of the Survey—Sir William Logan, Alexander Murray, T. Sterry Hunt, and E. Billings. Montreal: Dawson Brothers. London: Baillière.

The wells of this district are chiefly in an area of about four square miles in the first three ranges of Enniskillen. When these wells have been opened, the petroleum has risen to the surface of the earth, constituting what are called "flowing wells." One of these, which was sunk to a depth of about 200 feet, is said to have yielded, when first opened, not less than 2,000 barrels in twenty-four hours. The Enniskillen petroleum wells have produced as follows from the time of their opening:—

	Barrels.
Previous to July 31, 1861	5,529
Half-year ending January 31, 1862 .	6,246
Do. do. July 31, 1862 . .	25,264
Do. do. January 31, 1863 .	57,550
For the month of February 1863 . .	8,874
Number of barrels of 40 gallons each .	103,463

Giving a total yield of 4,138,520 gallons.

Other districts are named from which petroleum can be obtained, although as yet the quantities in which it is likely to be produced are uncertain, as no sufficient exploration has been made.

This Report, extending to 980 pages, is a valuable contribution to our scientific literature.

M. Damour has communicated a paper to the *Académie des Sciences* on the "Density of Zircons." He has given a long list of these precious stones which he has examined. We select the results obtained in a few instances only, as showing the variation of density to which they are subject:—

The Zircon of Ceylon—green colour .	4·043
Do. of India—blue tint . .	4·596
Do. of Brevig—brown . . .	4·613
Do. of the Ural—yellow brown .	4·669

The indices of refraction are shown to vary in these minerals with their density.*

A meteorolite found near Louvain, in Belgium, has been examined by M. Pisani, and found to contain—

Nickelliferous iron, with tin and traces of phosphorus	8·67
Pyrites	6·06
Chromate of iron	0·71
Silicates	84·28
	99·72

A full account of this stone was communicated to the *Académie Royale de Belgique*, and will be found in their Transactions. The *Académie des Sciences* of Vienna has also been occupied with the consideration of meteoric masses. M. Haidinger described the occurrence of meteoric iron found at Tucson, in the territory of Avezana, United States; and read a communication on a meteorolite observed at Vienna on the 10th

* 'L'Institut: Journal Universel des Sciences,' January 20, 1864.

of August.* M. Gustav Rose has communicated to the Academy of Berlin notices of six aërolites.†

M. Henry Sainte-Claire Deville brought under the notice of the Academy of Sciences a new mineral found by M. Breithaupt in Greenland, and to which he has given the name of Carphosiderite.‡ This mineral is very rare, and it was supposed by E. Harkort to be a subphosphate of the hydrate of iron; but Deville says:—"After the study which I have made of carphosiderite, I am able to say that it is a subsulphate of the peroxyde of hydrate of iron mixed with sand and a little gypsum."

An interesting paper has reached us on "The Gems of Australia," read before the Royal Society of Victoria, by Dr. Bleasdale. From this we learn that the following gems have been found in our important colony: §—Diamonds, sapphires, ruby, topazes, beryls, garnets, opals, amethysts, and jaspers. The ruby, of which one only has been found, alone requires notice. It was found in Queensland, "and cut in Melbourne by Mr. Spink, and turned out to be a star ruby, of good size and great beauty. This stone is, I think, new. It belongs to the Asterias, but instead of having a floating star of six rays of white light, it has a fixed star of six black rays in a deep blue ground."

Dr. Bleasdale offers some very sensible suggestions on the importance of instructing the gold miners in a knowledge of precious stones, and of forming a good collection of them in the local museums.

We conclude our chronicle of mineralogy by drawing attention to a machine recently patented (of which a working model is exhibited in Liverpool), for the reduction of "charcoal and other friable substances to fine or impalpable powder, particularly applicable to the manufacture of a substitute for lampblack." The apparatus is of the simplest kind, consisting in the main of cylindrical vessels, into which the material to be reduced is placed along with a great number of small balls or spheres of iron, glass, stone, &c., to which rotary motion is then imparted at any speed required.

The inventor claims for his machine the power to reduce a great variety of substances to an impalpable powder, as fine as lampblack; and amongst those named in the specification of patent are, colouring earths, barytes, marble, bloodstone, litharge, emery, gums, pepper, &c.

The invention is a Swedish one, and is in charge of Mr. Lee, 16, Leeds Street, Liverpool, who exhibits the working model.

Although the well-determined processes of metallurgy leave us nothing in the way of progress to record, our metal manufactures appear to advance with great rapidity. Our attention has been directed to a new process for drawing steel tubes, which is now exciting considerable interest. The following description, which is most exact, we borrow from 'The Times' newspaper:—

* See 'L'Institut,' February 17, 1864.

† See 'Les Mondes,' February 11, 1864.

‡ Breithaupt in Schweiger's Journal, Bd. L. S. 314.

§ See also Dicker's 'Mining Record and Guide to the Gold Mines of Victoria,' December 24, 1863.

"Steel tubes are one of the difficult problems of our hardware manufacture. They are very costly to produce, and very unequal in their tenacity when they are turned out, the weld, when the tube is joined down the middle, always proving its weakest and almost its unsafe part. Steel wires, however, of any thickness or of any fineness, are drawn every day, and by a very simple development of the same process a machine has been invented by which steel tubes of any thickness or internal diameter can be produced with the same certainty. In a few words, it may be said that the new method consists of substituting the slow, equal, but irresistible force of hydraulic pressure for the ordinarily rapid but somewhat uncertain steam power of the wire-drawer's bench. The whole machinery consists of a hydraulic press, with double cylinders placed *vis-à-vis* with a single piston, which as it leaves one cylinder enters the other, and which, at its junction between the two, carries a powerful collar or flange of iron. To this flange the steel tube to be drawn out is secured in a die or gauge of the requisite shape, while down inside the tube itself passes a steel rod, which fits into the circle of the die or gauge, just allowing the requisite aperture round its circumference to regulate the size of the tube drawn over it. Thus, when once the machine is set in motion by its pump, the tube, held by its outer collar, is slowly drawn over the inner rod, which, according to its thickness, reduces the tube by pressure against the outer die to any fineness, and therefore to any length that may be required. Several tubes were thus drawn yesterday in the presence of a number of engineers and scientific gentlemen at Mr. Almond's works, Willow Walk, Bermondsey; and the results, both as to the mechanical trueness of the tube and its perfect homogeneousness throughout, were in the very highest degree satisfactory. Nor is it circular tubes only that can be drawn by this process. By altering the shape of the outer die and inner rod to square, triangular, or octagon, the same form of tube is produced with equal certainty and equal strength, though in order to avoid distressing the metal it is only reduced $\frac{1}{16}$ of an inch at each passage through the machine. The movement is so slow that the tube comes out almost cold, yet burnished like the finest steel inside and out. The great pressure, however, to which it is subjected has a tendency to harden the metal, so that when many reductions of size are necessary, it has to undergo annealing to keep it at the required toughness. After being drawn to whatever shape or length is required, the finished tube can be tempered up to any degree of hardness, or annealed down to its strongest stage of toughness as may be wanted. The whole process is neither an invention nor a discovery, but simply a most valuable development of our present means of manufacture."

We understand that there are scarcely any limits to the sizes of which the tubes can be drawn. Within all the ordinary requirements of our engineers, drawn-steel tubes can now be supplied.

VI. OPTICS.

Since the beautiful researches of Faraday on gold-leaf, the relation of metals to light has scarcely met with the attention which so important a subject deserves. M. G. Quincke has recently published* an elaborate investigation on the optical properties of metals. We have not space even for an analysis of this long paper, but we will mention a few of the most important results at which he has arrived. Plates of gold, silver, and platinum were employed, so thin as to be transparent, and these were examined in the same way as other transparent bodies. When light falls upon a thick plate of metal it penetrates to a depth which is about as great as the length of an undulation, the so-called metallic lustre being produced by the conjoint action of the exteriorly and interiorly reflected or dispersed light. The velocity of light through metals is one of the subjects studied by the author, and he has obtained, in the course of this investigation, the remarkable result that light travels faster through gold and silver than through a vacuum. But Faraday has shown that silver and gold films occur in different modifications, and M. Quincke finds that gold and silver metallic plates, through which light passes with a greater velocity than through air, may become spontaneously altered by simple standing, so as to transmit light with less velocity than it is transmitted by air. In the case of platinum it was always found that the light passed through with less velocity than through air. The ordinary polished silver and gold possess the same character as that modification of these metals which transmits light with the greater velocity. Their refracting indices are therefore less than unity.

The second part of Kirchhoff's researches on the solar spectrum and the spectra of the chemical elements, translated by H. G. Roscoe, F.R.S.,† has just been published. It completes the Professor's survey of the solar spectrum, and contains two plates, one extending from A to D, and the other beginning at the point where the second plate in the former publication ended, and extending as far as G. The actual observations have been taken by M. K. Hofmann, a pupil of Professor Kirchhoff's, his own eyesight having been too much injured by his previous observations to allow him to continue the investigation. The new metals examined consist of potassium, rubidium, lithium, cerium, lanthanum, didymium, platinum, palladium, and an alloy of iridium and ruthenium. These additional observations have not yielded any new information respecting the constituents of the solar atmosphere; they have, however, confirmed the results of the previous examination. Potassium, which was formerly considered to give lines identical with some in the solar spectrum, now appears to be absent from that luminary; a few coincidences have also been observed in the spectra of strontium and cadmium, but their number is too small to warrant the conclusion that these metals are present in the sun's atmosphere.

* 'Poggendorff's Annalen,' vol. cxix. part 3.

† Macmillan and Co.

The plates are lithographed in ink of different tints, and form as perfect a representation of the spectrum lines as it seems possible to obtain.

M. Van der Willigen has communicated * the results of some determinations of the indices of refraction of twelve rays of the solar spectrum for distilled water. Every precaution has been taken to secure accuracy, and the readings have been taken to one second. We give the results for the eight Fraunhofer rays :—

A	1·32899
B	1·33048
C	1·33122
D	1·33307
E	1.33527
F	1·33720
G	1·34065
H	1·34350

A very interesting experiment in spectrum analysis has been described by M. Louis Grandeau.† During a stormy night he arranged a spectroscope at his window, so that the lightning could illuminate one-half of the slit, whilst one of Geissler's nitrogen vacuum tubes was sending its light in through the other half of the slit. A small quantity of vapour of water which remained in the nitrogen tube at the time it was prepared was sufficient to produce the characteristic ray of hydrogen superposed on the nitrogen rays. M: Grandeau was able for an hour, at intervals of about five minutes, to observe the spectrum of the lightning, the general appearance of which at first sight recalled that of the electric spark; but on closer observation he soon noticed in the spectrum of almost every flash the coincidence of a certain number of the rays of its spectrum with those of the spectra of nitrogen and hydrogen. This is easily understood when we remember that ammonia and nitric acid are produced under the influence of the electric discharge.

The solar radiation has long been supposed to exercise a marked action upon all bodies exposed to its influence. The difference observed between plants which have grown exposed to its full power, and others which have received but a limited share of its action, is generally very great. M. Bourgeois has lately made some observations on meadow grass, part of which was fully exposed to sunshine, whilst the other part was grown in a shady spot. After it had been converted into hay, that portion which had had the full benefit of the sun was greedily eaten by some horses, whilst they refused to touch that which had been grown in the shade. Upon subjecting the two kinds to distillation by steam the sunned portion was found to be much richer in odoriferous principle than the other. These experiments show that other evils besides actual paucity of crop spring from a dull cloudy summer and autumn, whilst sunshine, besides increasing

* 'Comptes Rendus de l'Académie des Pays Bas.'

† 'Practical Instructions in Spectrum Analysis.' Paris: Mallet Bachelier.

the actual yield per acre, causes it to grow of a much better quality. There is no doubt that what is here shown to be the case with grass holds good equally with cereal and other crops.

A lifetime might be spent in investigating the mysteries hidden in a bee-hive, and still half of the secrets would be undiscovered. The formation of the cell has long been a celebrated problem for the mathematician, whilst the changes which the honey undergoes offers at least an equal interest to the chemist. Everyone knows what honey is like when fresh from the comb. It is a clear yellow syrup, without a trace of solid sugar in it. Upon standing, however, it gradually assumes a crystalline appearance—it *candies*, as the saying is—and ultimately becomes a solid mass of sugar.

It has not been suspected that this change was due to a photographic action—that the same agent which alters the molecular arrangement of the iodide of silver on the excited collodion plate, and determines the formations of camphor and iodine crystals in a bottle, also causes the syrupy honey to assume a crystalline form. This, however, is the case. M. Scheibler* has enclosed honey in stoppered flasks, some of which he has kept in perfect darkness, whilst others have been exposed to the light. The invariable result has been that the sunned portion rapidly crystallizes, whilst that kept in the dark has remained perfectly liquid. We now see why bees are so careful to work in perfect darkness, and why they are so careful to obscure the glass windows which are sometimes placed in their hives. The existence of their young depends on the liquidity of the saccharine food presented to them, and if light were allowed access to this the syrup would gradually acquire a more or less solid consistency; it would seal up the cells, and in all probability prove fatal to the inmates of the hive.

The Magnesium Light is gradually attracting more and more attention, as there appears to be a probability of the metal being obtained at a reasonable price. At a recent meeting of the Manchester Literary and Philosophical Society, Professor Roscoe exhibited the light emitted by burning a portion of a fine specimen of pure magnesium wire, one inch in diameter. In a memoir on the subject by Professors Bunsen and Roscoe, they show that a burning magnesium wire 0·279 inch thick evolves as much light as 74 stearine candles, 5 to the pound. In one minute about ·12 grammes of magnesium would be burnt, and in 10 hours about 72 grammes or a little over 2 ounces. In order to produce the same light with the candles for 10 hours, there would have to be burnt about 20 lb. of stearine, so that could magnesium wire be produced at a few shillings per ounce our houses might at once be illuminated by this easily managed and intensely powerful light.

A good photometric process, easy of application, and tolerably accurate in its results, is, and perhaps will long remain, a desideratum. One of the best which has come under our notice has just been devised by M. Z. Roussin; he dissolves equal parts of dry perchloride of iron

* 'Journ. de Pharm. et de Chimie,' 1863.

and nitroprusside of sodium in ten times their weight of water, and in this manner forms a liquid which is highly sensitive to light, deposing Prussian blue as a precipitate under the influence of luminous action, whilst it remains quite clear in darkness. He therefore prepares this liquid in obscurity, and takes its specific gravity. After exposure to the light he filters off the precipitated Prussian blue, and again takes the specific gravity of the clear liquid. It will of course have diminished in density by the amount of solid matter separated, and the difference between its former and latter specific gravity will represent the chemical action, the numbers obtained varying directly with the intensity of the light.

The Electric Light appears to have permanently taken its place amongst theatrical properties. In Paris, where more attention is paid to scenic effects than in this country, the celebrated optician Duboscq has devised some marvellous imitations both of lightning and of the rainbow. The former is obtained by a concave mirror, in the focus of which are the two carbon poles of a powerful battery nearly in contact, and so adjusted that when the mirror is rapidly moved in the hand the poles are caused to touch for a brief interval, and flash a dazzling beam of light across the stage. The zigzag effect of lightning, and its peculiar blue colour, are very perfectly imitated by this means. But more wonderful than this is the rainbow. In the representation of the opera of *Moïse* it is requisite in the first act to introduce a rainbow, and this has hitherto been effected either by painting or by projecting the image on the scene from a magic lantern by means of a coloured slide. In the latter case the stage had to be darkened in order to allow the rainbow to be seen, and this of course destroyed the illusion. M. Duboscq, by a happy modification of his spectrum apparatus, and by employing a curved instead of a straight slit, and a small-angled prism, has succeeded in projecting the very brilliant electric spectrum on the scene, with the proper curvature and the identical colours of the real rainbow, and this of such a vividness that it is plainly visible in the full light of the stage. In these days of sensation-spectacles we feel confident that a real rainbow on the stage would attract quite as crowded houses as a "tremendous header," and it is somewhat surprising that no manager thought of introducing so novel an effect last Christmas.

If our Continental neighbours have not yet supplied us with all their electric effects, they have not hesitated to make full use of the Dirksian ghost, which has so long reigned unrivalled at the Polytechnic under the energetic management of the director, Mr. Pepper. In the last act of the '*Secret de Miss Aurore*,' as performed at the Théâtre Impérial du Châtelet, the ghost of Conyers is made to confront his assassin, Softy, with incorporeal bank-notes in his hand, and poetic justice is supposed to be avenged by the horror which seizes the murderer when he finds himself unable to grasp them. But the head-quarters of the ghostly illusion are at the *Séances* of M. Robin, perhaps the most scientific of modern followers of Cagliostro. In availing himself of the now well-known machinery necessary to produce the ghost illusion, he combines the experience of a wizard with the appliances of a man of science, and succeeds in producing some of the most startling illusions of the day. He does not attempt to instruct his audience, but candidly tells them that he is going to employ the whole of his complicated electrical, voltaic, and optical machinery to deceive their eyes and to astonish them. No one can say that he does not succeed in both these attempts. His scene of "the violin of Paganini," and the one in which he represents himself as struggling in the embrace of death, are perhaps the most real illusions which have ever been brought before the public.

VII. HEAT.

The determination of the mechanical equivalent of heat has been one of the great triumphs of modern times. The numerical relations have been obtained by many experimenters, but the methods have been liable to very great errors of manipulation. One of the most accurate series of determinations has just been completed by MM. Tresca and Laboulaye.* The principle upon which they work is to allow a given volume of air to expand, and then to measure the amount of heat which it has absorbed during the operation. Into a reservoir holding 3·28 cubic metres, air is forced until it has a pressure of three atmospheres. A mercury gauge is connected with the receiver, and a float on the upper portion of the mercury registers mechanically its exact height at any given moment. This is effected by having connected with the float a needle-point pressing against a sheet of glass which is blackened with smoke, and carried horizontally forward by clockwork. It is evident, therefore, that the variations in height of the mercury column communicating a vertical movement to the needle, whilst the glass screen is carried forward horizontally, the resulting mark will be a diagonal varying in curvature with the variation of height of the mercury gauge. The exact height of the mercury column can, therefore, be ascertained at any desired moment.

The reservoir being filled with pure dry air at a pressure of three atmospheres, and the mercury column being stationary, the needle-point registering a perfectly straight line on the screen, a stopcock is opened and air is allowed to rush out for a certain time, say five seconds; it is then closed. As soon as the air commences to rush out, and the gaseous mass suddenly expands, its pressure diminishes, and the needle-point consequently gives a downward oblique mark on the glass plate. But in expanding, the temperature of the gas sinks, and when the stopcock is closed the remaining gas in the reservoir has a lower temperature than the reservoir itself or the surrounding bodies. The mercury gauge, therefore, stands at a lower point than it otherwise would, had the temperature remained uniform.

Upon closing the stopcock, the gas, absorbing heat from the sides of the vessel, gradually regains its original temperature, and the mercury gauge commences to raise the needle-point, registering an upward curve until the temperature is in equilibrium; it then registers a straight

* 'Comptes Rendus de l'Académie des Sciences,' February, 1864.

line once more. Another observation is now taken, and this is repeated for an indefinite number of times; the mean result being capable of any degree of accuracy according to the number of observations from which it is deduced. It will be seen that the reservoir and mercury gauge constitute a gigantic air thermometer, and the method of registration is capable of giving the most minute variations of temperature. The amount of *work* done by the sudden expansion of the gas has a fixed value in thermometric degrees, and the tracings on the glass plate hold all the data required to give the exact numerical relation between the two. We will not follow our authors into the details of their calculations, but will state from the results of their investigation, that the number 476 formerly used must be changed for that of 433, which is near that given by the labours of M. Seguin and Mr. Joule. From the method of operating, and the large scale upon which the work has been conducted, there is every probability of this number being very near the truth.

In our last Chronicles of Science we gave a short notice of a new gas-furnace by Mr. G. Gore, of Birmingham. The same principle has since been applied upon a much larger magnitude, and furnaces on a commercial scale are now in use at the electro-plate manufactory of Messrs. Elkington, Birmingham, and elsewhere. These larger furnaces, as at present constructed, are capable of melting about 400 ounces of silver, copper, gold, German-silver, or if desirable, even cast-iron. The amount of coal-gas consumed varying from 300 to 400 cubic feet per hour.

With a consumption of 360 cubic feet per hour, the following results have been obtained:—266 ounces of sterling silver were perfectly melted within 25 minutes from the period of lighting the gas in the cold furnace, and the metal was sufficiently hot to cast for rolling in 20 more minutes. A second quantity of 266 ounces of the same metal was then introduced and was perfectly melted in 11 minutes, with a consumption of 66 cubic feet of gas, value 2*d*., the price of gas being 2*s*. 8*d*. per 1,000 feet; in a further period of 15 minutes the metal was sufficiently hot to cast for rolling. A quantity (116 ounces) of German-silver was then introduced and melted in 15 minutes, and, after 28 minutes' longer heating, various highly-figured articles were cast from it in a most perfect manner. In a subsequent operation 460 ounces of silver were melted in about the same time, and with an expenditure of scarcely more gas than was required to melt 266 ounces.

The smaller sizes of this furnace are much used by dentists, jewellers, analytical chemists, assayers, enamellers, and others, in consequence of their readily fusing silver, gold, copper, glass, and even cast-iron, without the aid of a bellows or lofty chimney, by simply lighting the gas; and the crucible and its contents being at all times protected from the air and yet perfectly accessible for examination, stirring, removal, &c. The burners of the larger-sized furnaces are formed of a series of plates of cast-iron, and may be readily removed from the furnace and placed to heat a retort, muffle, reverberatory chamber, or other apparatus, where intense heat is required; it is intended to apply them to heating steam-boilers and welding articles of wrought iron.

The safety of these furnaces, their regularity and self-supplying action, and perfect freedom from dust and smoke, render them advantageous in certain processes, such as enamelling, annealing, &c., where cleanliness and uniformity of heat are required. Their high degree of heat without the aid of a blast results from the very rapid and perfect mixture of the air and gas, and the combustion being consequently effected and concentrated in a very small space.

To provide for cases where gas is not available for the production of these high temperatures, and a more cleanly and manageable source of heat is required than that afforded by a coke furnace, Mr. C. Griffin,* has constructed an oil lamp for use with an artificial blast of air, which is not only as powerful in action as the best gas furnaces, but almost rivals them in convenience and economy. The fuel is the more volatile kind of mineral oil of the specific gravity ·750; every precaution is taken to prevent any danger of explosion by the sudden or accidental ignition of the vapour. The flame produced in this furnace is as clear as that of an explosive mixture of air and coal gas, and it is perfectly free from smoke. No chimney is required. The power of the furnace is very great: starting with a furnace quite cold it will melt one pound of cast-iron in 25 minutes, 1½ lb. in 30 minutes, 4 lbs. in 45 minutes, and 5 lbs. in 60 minutes; the cost of the latter experiment being about 9*d.* for oil. In all cases where gas cannot be obtained as a fuel for such operations, this oil-lamp furnace cannot fail to prove of very great value.

Oxygen, that fierce supporter of combustion at ordinary pressures, would have its energy increased to an inconceivable extent if used in a highly-condensed form. An observation of Dr. Frankland has shown that under this condition a solid mass of iron is almost as inflammable as phosphorus in the ordinary state of the atmosphere. During some experiments at the Royal Institution he was condensing oxygen gas into the strong iron receiver of a Natterer's apparatus, and had got the pressure up to 25 atmospheres when the vessel burst with a loud explosion, sending a shower of brilliant sparks in every direction. Upon subsequent examination it was seen that the whole of the interior of the receiver and the solid steel plugs had been eaten away to the depth of an eighth of an inch, and was covered with a fused mass of oxide of iron. The heat evolved in the compression had evidently ignited the oil used to lubricate the piston; this immediately caused the combustion of the iron which, in the atmosphere of compressed oxygen, proceeded with great intensity; there can be scarcely a doubt, the Professor considers, that had a union joint not given way, and thus furnished an outlet for the compressed gas, the latter would in a few seconds more have converted the receiver into a most formidable shell, the almost inevitable explosion of which would have scattered fragments of intensely-heated and molten iron in all directions.

The observations of Professor Tyndall on the physical properties

* 'Chemical News,' vol. ix. p. 3.

of ice, and the interest excited by his remarkable book "*Heat as a Mode of Motion*," have caused physicists in other countries to direct their attention to this subject. Professor Reusch, of Tübingen, in a letter to Dr. Tyndall,* describes some observations which he has made on this body. A long narrow plate of clean ice was suspended by its two ends in loops of silk, whilst a third loop, hung from its centre, had a small weight attached to it. After the lapse of 20 or 30 minutes a bending was plainly seen, the ice comporting itself like a plastic body; once indeed he was able to bend a thin lamella of ice between the fingers of both hands. In preparing these plates it was noticed that in sawing through ice, the saw after a time ceases to act, the space, between its teeth becoming filled with freshly-formed ice, so that it passed along almost without friction The saw, in fact, melts through the ice, the heat necessary for that being the equivalent of the work applied to the saw. In dividing plates of ice it is necessary to handle them like glass. If the convex blade of a knife be passed over a piece of ice with a certain pressure a sharp crack will result, and the plate may be broken in the direction of this crack, provided the temperature of the ice and of the air be below 0° C. Obviously the knife acts in this instance like a diamond, which depresses minute particles of glass, and through the wedge action of which a progressive linear cracking is produced, which renders fracture possible. A mere scratch suffices neither for glass nor for ice.

VIII. ELECTRICITY.

A NEW insulating material has been recently imported by Sir W. Holmes from Demarara, which bids fair to be a formidable rival to gutta-percha. It is the dried juice of the bullet tree (*sapota mulleri*) and is called balata; it appears likely to be more valuable than India-rubber or gutta-percha by themselves, as it possesses much of the elasticity of the one and the ductility of the other, without the intractability of India-rubber, or the brittleness and friability of gutta-percha, whilst it requires a much higher temperature to melt or soften it. Since the Exhibition of 1862, Sir W. Holmes, who was the Commissioner representing the colony of British Guiana, has been engaged in investigations how to produce the material cheaply, and how to dry or coagulate it rapidly; he has now succeeded so far as to warrant the importation of steam machinery to be applied for its extraction, and there appears to be every probability that balata will become an important article of commerce, supplying the great want of the day, a good insulating medium for telegraphic purposes. Messrs. Silver & Co. have already imported many tons of it, and Professor Wheatstone is now investigating its electrical and insulating properties. Another substitute for gutta-percha, the juice of the *alstonia scholaris*, a tree belonging to the natural order apocynea, has been forwarded from Ceylon by Mr. Ondaatjie; it is stated to possess the same properties, and to be as

* Philosophical Magazine,' vol. xxvii. p. 192.

workable as gutta-percha. It readily softens when plunged in boiling water, is soluble in turpentine and chloroform, receives and retains impressions permanently, and is adapted for seals to documents. These specimens are sent in response to premiums offered by the Society of Arts for the discovery of a substitute for gutta-percha.

A curious fact has been mentioned by Mr. James Napier* in reference to the dynamics of the galvanic battery, which is somewhat in opposition to the polar theory with mutual transfer of elements, advocated by Professor Williamson. Suppose a vessel divided by a porous diaphragm has dissolved in each division an equal quantity of sulphate of copper, and into each of the divisions is placed a plate of copper attached to the poles of the battery which completes the circuit; now, by the polar theory there should be a mutual transfer of the acid and copper between the two divisions, so that at any time, if the current of electricity were stopped, the solution in the two divisions would be the same as when the experiment began. But in reality this is not the case, the copper dissolved in the division attached to the zinc end of the battery will be deposited as metal on the copper plate in that division, while the acid element will be transferred to the other division. But the copper in that other division will not pass through the diaphragm in the opposite direction to the acid, so that ultimately the one division will have neither copper nor acid in solution, whilst the other division (that connected with the copper end of the battery) will have double the quantity of sulphate of copper in solution that it had at the commencement.

The electrical properties of pyroxiline paper and gun cotton have long been known to be very great, but it has only lately been pointed out by Professors Johnstone and Silliman† that these azotized species of cellulose are the most remarkable negative electrics yet observed; upon friction with these, sulphur, hitherto the most highly negative electric known, becomes positive.

We have to thank Mr. Nassau Jocelyn, of the British Legation, Turin, for drawing our attention to a novel voltaic arrangement devised by Professor Minotti, of that city, which, though essentially based upon Daniell's principle, is said to be far more constant and powerful than any other arrangement of that rheomotor. It consists simply of a copper disc placed at the bottom of a glass vessel having a gutta-percha-covered wire soldered to its rim, which issues from the top of the vessel and forms the positive electrode. Over the copper is laid a layer of powdered sulphate of copper, and over this a stratum of coarse sand, or—what has been found to answer better—a stratum one inch in thickness of common glass beads, such as are used for working purses, and may be purchased at a cheap rate at the workshops. On this layer lies a solid cast-cylinder of zinc, from whence proceeds the negative pole of the element. On the cell being filled with common spring water, so as to cover the zinc, the battery begins to work, and will keep constant and uniform for seven or eight months. The intensity of

* 'Philosophical Magazine,' vol. xxvii. p. 52.

† 'Silliman's Journal,' January, 1864.

the action may be judged by measurement with the galvanometer, which will be found in a cell where the copper and zinc surfaces are about 3 inches square each, to have its needle deflected to about 20°. This is in the case of the meter ordinarily employed by telegraphists. The power may be increased by approaching the elements of the cells nearer to one another, by placing the copper *over* the sulphate, and by reducing the beads to half an inch. There is, however, danger in this case of the accumulating surface of copper on the copper plate, crystallizing in an upward direction, and ultimately shooting out a fibre which may touch the zinc plate above it, when of course the cell would cease to work. The first arrangement is the best, and it is the one which M. Bonelli has adopted in working his new telegraph. The above battery appears to be the simplest yet brought before the public, consisting as it does of easily procurable materials, and its action being only limited by the waste of zinc and evaporation of water. M. Bonelli uses 30 cells to work his five-wire telegraph for a long distance, so that 6 cells appear amply sufficient per wire.

IX. PHOTOGRAPHY.

Iodide of silver may be looked upon as the foundation of the present photographic art, and yet up to a very recent period, men of science have differed in their opinion as to whether this compound is photographically sensitive *per se* or not. As late as January last, we find a foreign photograher, M. Gaudin,* publishing some experiments which tend to show that iodide of silver, when prepared by the direct combination of iodine and silver-leaf, is absolutely insensitive to light when tested under a negative, and that an hour's exposure in the printing frame does not give rise to any impression whatever, either before or after the application of a developing agent. The iodide of silver used in these experiments was in the form of a yellow powder, rather unctuous to the touch, and was merely rubbed over the surface of a piece of paper with a tuft of cotton. Subsequent experiments were tried in which the iodide of silver, after being rubbed over the paper, was exposed to the vapours of nitric acid, hydrochloric acid, and ammonia: the last only gave signs of a picture, and that only after a very long exposure. These experiments tend to confirm what is generally stated in chemical works; but Mr. Spiller † has since communicated some further results, tried with that care and ingenuity which are so well known to those who are familiar with the published researches of this chemist, which show conclusively that iodide of silver exists in two different modifications, one of which is insensitive, whilst the other is sensitive to the action of light. Reasoning upon the well-known change which takes place when iodide of mercury is heated—its scarlet colour changing to yellow—it occurred to him that a similar change might possibly be induced in the iodide of silver. This

* 'The Photographic News,' vol. viii. p. 8. † Ibid. vol. viii. p. 15.

was confirmed by experiment, and by the application of heat alone the indifferent yellow iodide of silver becomes so changed in its properties, as afterwards to darken on exposure to sunshine much in the same way as the ordinary modification of bromide of silver. Very little apparent change is produced by the action of heat; at the most, the iodide can be said only to lose in a trifling degree the brilliancy of its yellow colour, verging a little towards grey. The lowest limit of temperature at which this change takes place is 350° Fahr.; and if the heat be augumented to 400° and upwards, the change is more rapidly effected. On increasing the heat, the iodide fuses to a dark-red fluid, which cools to a pale yellow semi-transparent mass, quickly affected by exposure to light.

Photographers are gradually recognizing the truth of what Sir William Newton urged more than ten years ago, namely, that it is possible to have pictures too sharp, and that the most artistic portraits were frequently those which were not absolutely in focus. One of our first writers on Art Photography has lately urged, in the 'British Journal of Photography,' the beauty of effect arising from slight want of sharpness. What artists call "hardness," is generally that effect which photographers call "sharpness;" and he maintains that far more pleasing portraits would be obtained were photographers to use their "long, long pencils of light much as artists use their drawing pencils,—that is to say, with a somewhat broad instead of an extremely sharp point." Although to an ardent photographer such doctrines may savour of rank heresy, we honestly confess that we have seen far more pleasing portraits taken in accordance with this artistic theory than when they were focussed with microscopic accuracy.

A writer in 'La Lumière' proposes a novel lantern for evolving light sufficient for taking portraits at night. A furnace is constructed, fed with hard retort carbon, and supplied, not with air alone, but with a mixture of oxygen and air: the oxygen being evolved from a mixture of binoxide of manganese and chlorate of potash, contained in a cast iron bottle placed beneath the furnace. In a small furnace furnished with a good draught, and only supplied with air, a light was obtained equal to 100 candles, and the author thinks that if fed with oxygen, the light would be equivalent to 1,000 candles. We do not glean from his description that such an experiment has been actually made, and we are tolerably confident that the difficulties in its practical accomplishment would prove too great to supersede other sources of artificial light, which have been recently introduced.

The Electric light has always been a favourite amongst advocates of night photography. At a recent meeting of the American Photographic Society, Mr. J. A. Whipple, of Boston, exhibited some photographs of a fountain in Boston Common, taken at about ten o'clock in the evening, whilst illuminated with the electric light. The exposure was 90 seconds, and from a comparison of the effect produced when photographed in daylight, it was estimated that the intensity of the electric light as compared with that of weak sunlight, was in the proportion of 1 to 180, half-a-second only being necessary to produce a similar picture in the daytime.

The electric light, hitherto without a rival, is likely to be equalled in brilliancy, and far surpassed in convenience and cheapness, by the magnesium light. In our chronicles of the progress of optical science, we have given an account of this truly wonderful light, and we have to add here some notes respecting its photographic value. At a late meeting of the Literary and Philosophical Society of Manchester,* Professor Roscoe exhibited some prints of a portrait which Mr. Brothers and he had taken at 5 o'clock p.m., on the 22nd of February, by burning 15 grains of magnesium in the form of fine wire at a distance of about 8 feet from the sitter. The negative thus produced was stated by Mr. Brothers to be fully equal to any obtained by sunlight in the most favourable state of the atmosphere, and the distribution of light and shade was most agreeable, harshness of the shadows being completely avoided by slightly moving the wire whilst it was burning. The magnesium was worth about sixpence. Photographers are now eagerly asking for supplies of this metal, and if the wire can be got for anything like a reasonable price, there is no doubt that in this climate, at all events, this application of it is likely to inaugurate a new era in the photographic art.

A very ingenious application of Professor Graham's discoveries in the diffusion of liquids has been just made by Mr. Spiller. In washing photographic prints it has been noticed that the first portions of hyposulphite of soda are easily extracted, whilst the last portions are only removed from the paper with great difficulty. This is explained by the great diffusive power into plain water of a strong solution of hyposulphite of soda over a weak one. After the first portions of hyposulphite have been removed from the print, Mr. Spiller† proposes to transfer them into a cold saline liquor made by dissolving a pound of salt in half-a-gallon of water; they are left there for fifteen or twenty minutes, when it is found that the salt brine has thoroughly penetrated the pores of the paper, and expelled the greater part of the remaining hyposulphite. The liquid is then poured away, and the prints are washed in common water. The principle of diffusion now comes into play again, and the salt brine rapidly soaks out of the paper, bringing with it the last traces of hyposulphite; by finally washing in the ordinary manner, an unusual degree of purity is attained, the presence of hyposulphite in the finished proof being rendered impossible. This is one of the most beautiful applications of a recondite scientific principle which we have ever seen.

The detection of hyposulphite of soda in the finished proof, or in the last washings, is a matter of some importance. Mr. E. J. Reynolds has communicated to the 'British Journal of Photography,' a series of experiments on the various methods at present in use. The first consists in reducing the hyposulphite to the state of sulphide by boiling

* 'Proceedings of the Literary and Philosophical Society of Manchester,' No. 13, p. 241.

† 'The Photographic News,' vol. viii. p. 113.

first with acid, then with alkali, and then adding nitro-prusside of sodium; this communicates a beautiful violet colour. The next consists in adding sesquichloride of iron, which at once gives a purple red tint if hyposulphite be present. The third test consists in adding iodine and starch, the blue colour of which is immediately discharged on the addition of a few drops of a solution containing a minute trace of hyposulphite. This reaction is very delicate, as it is capable of detecting one grain of the salt dissolved in 2¼ gallons of water. The fourth mode of detecting hyposulphite is based on the property which it has of reducing sesquichloride of iron to the protochloride. The suspected liquid is boiled in a small flask, with four or five drops of the iron solution, and a drop of red prussiate of potash is added. If hyposulphite be present, a blue precipitate or coloration is produced. This will detect one grain of the salt in four gallons of water. The fifth and most delicate test of all is obtained by introducing a few drops of hydrochloric acid, and a fragment of zinc into the suspected liquid, and testing the evolved gas for sulphuretted hydrogen by means of lead paper. This is so sensitive that it will detect one grain of hyposulphite in rather more than seven gallons of water. For the purpose of detecting any hyposulphite in the finished picture, the plan adopted by Mr. Spiller is the most convenient; he moistens the white parts with a little protonitrate of mercury, when the presence of even a trace of hyposulphite is shown by the production of a brown or black stain.

Few things are falsified more than the chloride of gold and the aurochloride of sodium used by photographers for toning their prints. The usual adulterant is common salt, which is sometimes added in such quantity that a bottle professing to hold seven grains of gold sometimes contains only a little over two. The editor of the 'Photographic News' has published a very simple mode of detecting this adulteration. Both the chloride of gold and aurochloride of sodium are soluble in alcohol, whilst chloride of sodium is insoluble in that liquid. The photographer has, therefore, only to stir up the contents of a fifteen-grain tube with alcohol, and the amount of white crystalline residue will show how much common salt has been sold to him at the price of gold.

M. Quaglio, an engineer of Vienna, has investigated the properties of oleate of silver, or silver soap, in photolithography. After some preliminary preparation, the lithographic stone is covered, with the aid of a flannel rubber, with the silver soap, and it is then exposed under a negative to the sun. The portions unacted upon are then dissolved out with naphtha, and the stone is ready to be gummed and inked in in the ordinary way. This process is extremely easy and appears likely to be successful. The impression is obtained direct from a negative, a transparent positive not being required, as in some other processes.

The substitution of a less expensive metal for silver has been the dream of photographers for many a year. M. Liesegang describes, in the 'Moniteur de la Photographie,' a process devised by M. Obernester, of Munich, which seems to be very successful. The paper is first washed with a mixed solution of sesquichloride of iron and chloride of copper. The paper after drying is ready to be exposed in the printing frame; its sensitiveness is one-third greater than that of albuminized paper. Very little is seen on removing it from the printing frame, but it is partially developed by floating it on a solution containing sulphocyanide of potassium and a little sulphuric acid. The effect of this is to precipitate white subsulphocyanide of copper, upon those parts of the paper upon which the light has acted. After washing for an hour or two, the picture can be obtained of different colours by dipping it into appropriate solutions. Thus, red prussiate of potash gives them an intense red hue; by acting on this with an acid solution of iron they become violet red, violet blue and black, and after coating them with albumen, it is impossible to discover any difference between them and the best silver proofs upon albuminized paper.

X. ZOOLOGY AND PHYSIOLOGY.

The French Academy, whose annual meeting took place at the close of the year, occupied itself with a tribute to the distinguished and lately deceased zoologist, André Dumeril, and then proceeded to announce the prizes which it proposed to offer for the coming year, by means of which it may be hoped new impulse may be given to the various departments of science. The great Physical Science Prize of 3,000 francs has been postponed from 1859 to 1st of September 1864; the subject is " The Comparative Anatomy of the Nervous System of Fishes." Another prize of the same value has been postponed from 1861 to December 31st 1865; the subject is, "The Production of Hybrid Animals by means of Artificial Fecundation." A third prize of 3,000 francs is offered for the osteographical work which will best contribute to the advancement of French palæontology, to be sent in by 1st of November 1865. The Cuvier prize, to be awarded in 1866, will be given to the most remarkable work upon the Animal Kingdom, or upon Geology. This prize is awarded every three years,—the funds arising from unemployed subscriptions to the statue of Cuvier; it has just been awarded to Sir R. Murchison for his works upon the Palæozoic formations. Another Cuvier prize is also announced to be given to the author of the most remarkable work upon the Animal Kingdom, or on Geology, which shall appear between the 1st January 1863 and the 31st December 1865. The prize to consist of a gold medal, value 1,500 francs. Another prize, termed the Godard prize, of 1,000 francs, is given annually to the best paper on a physiological subject, which is this year left open.

Although some of these prizes, owing to the extended character of the researches required, have been necessarily postponed from year to year, it is not therefore to be supposed that there are no competitors, or that this stimulus is offered in vain. Other prizes of a similar character were awarded at the meeting of the Academy, as the first prize in Experimental Physiology, which was given to M. Moreau, for a work "On the Air-bladder of Fishes," while a second was given to MM. Philippeaux and Vulpian, for some "Researches on the Reunion, end to end, of Nervous Sensitive Fibres with Nervous Motor Fibres." The second Bourdin prize was unanimously awarded to M. Lacaze Duthiers, for his anatomical and physiological history of coral, and other zoophytes.

The practice of vivisection in Paris, which has received so much public notice of late, has recently been brought before the French Institute. It will be recollected that a visit was made to the Veterinary College at Alfort, by delegates from the English Society for the Prevention of Cruelty to Animals, and the adhesion of the Director of that Institution, so notorious for its torturing practices, was secured. The Emperor also promised the deputation that he would institute a scientific commission into the subject, and that promise he has kept, though the result appears not to have been unmixed good. M. Robin, formerly an opponent, has become a violent partisan of the practice of vivisection. In anticipation of the struggle about to take place between the advocates of the two systems, a regular correspondence has been opened between the different Academies of Europe, and the opinions of scientific men of all countries are eagerly collected. The first communication, recently made to the Institute, was from Professor Lusana, of Pisa, who described the processes by which he had succeeded in extracting the pneumo-gastric nerve from dogs and rabbits, after numerous attempts. The result of this frightful operation appears to be that the victim becomes insensible to the strongest poisons, and that even strychnine may be introduced into the stomach with impunity. But however curious and interesting this fact may be to the physiologist, we cannot see that any very practical results may be drawn from it; and we trust that the more humane physiologists who engage in the controversy, may not be dazzled by the spurious brilliancy of such a discovery into the reprehensible practice of systematic torture of dumb animals.

The period of gestation of certain animals of the class of Ruminants, which habitually breed in the Zoological Society's menagerie, has been ascertained with tolerable exactness by Dr. Sclater, the Secretary. Of course the period is slightly variable, but the times given in the following list are, on the average, very faithfully adhered to.

Fam. *Cervidæ.*—The following have a period of eight months: Wapiti Deer (Cervus Canadensis), Persian Deer (C. Wallichii), Barasingha Deer (C. Duvaucelii), Japanese Deer (C. Sika), Sambur Deer (C. Aristotelis), Rusa Deer (C. Rusa), Hog Deer (C. porcinus), Axis Deer (C. Axis).

Fam. *Camelidæ.*—Llama (Auchenia glama), and Alpaca (A. pacos), both have a period of eleven months.

Fam. *Camelopardidæ.*—Giraffe (Camelopardalis giraffa), fifteen months.

Fam. *Bovidæ.* — Punjaub wild sheep (Ovis cycloceros), and Moufflon (O. Musimon), each four months; Leucoryx (Oyx leucoryx), eight months; Eland (Oreas Canna), nine months; and Nylghai Antelope (Portax picta) between eight and nine months.

The Hippopotamus has twice produced young in the Amsterdam Gardens,—on the first occasion she went seven months and sixteen days, and on the second seven months and twenty days.

Mr. Sherbrooke Walker, who has lately come from New Zealand, brought with him some fine bones of the Moa (*Dinornis giganteus*, Owen), which he has deposited in the Liverpool Museum in very perfect condition. They consist of right and left femur, two left tibiæ, two left metatarsi, and two vertebræ. These bones were found in a limestone cave at Blue Cliff station, in the province of Canterbury, to enter which the explorers had to let themselves down by a rope, and crawl in on their hands and knees. Mr. Walker reports that the Maories assert that formerly the Moa was very numerous, and used to kill the native children, so that they at length determined to exterminate the birds, and to burn the island for this purpose; and, according to them, on a day fixed upon, the whole of the east coast was fired at the same time. Whether this be true or not, it is very evident that all the east side of the middle island was once heavily timbered, for go where you will, on hills or plains, you will find large burnt logs of a species of pine, called by the natives *Totara*, which never decays in the ground; and also, more rarely, logs of a species of cedar, now extinct there. These logs are only charred on the outside. Wood, however, still exists on the island which may have been protected by a swamp or river, in which swamps Moa bones are sometimes found, as though they had found shelter there. Mr. Walker is incredulous of this Moa still being existent on the island, and only heard of one person who professed to have seen one, when a child. The Maories also have a tradition that these birds used to go into caves, and that their ancestors made large nets of New Zealand flax (*Phormium tenax*) for the purpose of catching them for food.

Mr. Walker describes the habits of another remarkable New Zealand bird, the Owl Parrot (*Strigops habroptilus*, G. R. Gray), called *Rakapo*, by the natives, found chiefly in the Middle Island. It is about the size of a common hen, with a varied black and green plumage, evidently a nocturnal bird, always hiding itself under some thick plant in the daytime. It cannot fly at all, and has a very singular mode of progression, giving a hop forward, and then putting its head down, and resting its forehead on the ground. Mr. Watts Russell, who has had frequent opportunities of observing these birds in their native haunts, confirms this singular account of their using their head as a third foot. It is entirely a ground bird, and in appearance singularly resembles an owl.

While on the subject of Struthious birds, of whch the Moa was a grand type, it may be mentioned that Professor Hincks, of Toronto, in a paper recently published on their systematic relations, remarks that those who have arranged them among the Rasores have been guided by real and important analogies—those who have placed them among Grallatores have attached undue importance to a single character, which really only indicates the position of this in reference to the other families of Rasores—and those who have elevated this group to the rank of one of their great orders of birds have chiefly manifested their hesitation between the other two views, by taking a sort of intermediate position. The position of Apteryx, that most remarkable New Zealand bird, as a type of a sub-family of Struthionidæ, seems to be conceded; and its long, narrow beak, with the nostrils at the extremity, is so especially tenuirostral, that there can be little doubt about its fittest place, though its entirely suppressed wings and hair-like feathers might seem to mark it as last in the circle, because lowest in development.

Captain Mitchell, of the Madras Museum, confirms the accounts of the climbing habits of the fish, *Anabas scandens*, and asserts that it *does* ascend the palm-trees, suggesting that as it does so after heavy monsoon rains, it may be that it prefers pure rain-water to the muddy water found in the pools and streams at those times. The native assistant at the Madras Museum states that he has *seen* them climb. He says:—"This fish inhabits tanks or pools of water, and is called *Panai zéri*, *i. e.* the fish that climbs Palmyra trees. Where there are Palmyra trees growing by the side of a tank or pool, when heavy rains fall, and the water runs profusely down their trunks, this fish, by means of its opercula, which move unlike those of other fish, crawls up the tree sideways to a height of from five to seven feet and then drops down. Should the Anabas be thrown upon the ground, it runs or proceeds rapidly along in the same manner (sideways) so long as the mucus on it remains." This sideways movement, by inclining the body considerably from the vertical, enables the fish to use the spines on the operculum to the best advantage. The operculum itself is remarkably movable, and the locomotion is described as a wriggling one. Other observers have satisfied Captain Mitchell that they have seen the Anabas ascend Palmyra trees at Negapatam and in the neighbourhood of the Red Hills, in the vicinity of Madras.

M. Moreau arrives at the following conclusions relative to the air in the swimming-bladders of fishes:—This air presents a composition which may vary more or less, relatively to the proportion of oxygen under the following circumstances: 1. The oxygen diminishes and disappears in asphyxia and other morbid conditions. 2. In fishes with an open, as in those with a closed, swimming-bladder, the air is renewed without being derived from the atmosphere, and the rapidity of this renewal is in proportion to the vigour of the fish. 3rd. The new air presents an amount of oxygen far superior to the proportion of gas usually contained in the air of the swimming-bladder, and also far superior to that contained in the air dissolved in the water.

The Entomological Society of New South Wales in the first part of its Transactions lately published, gives a description of an ovo-viviparous moth of the genus Tinea, which he calls *Tinea vivipara*. It was captured after dark early in October, and fearful that the plumes might be injured by its struggles, it was gently compressed, and on opening the hand Mr. Scott observed numbers of minute, but perfect larvæ being ejected from the abdomen in rapid succession, and moving about with considerable celerity, evidently in search of suitable food or shelter. Several other specimens were subsequently obtained, and they shortly commenced to deposit their living progeny with rapidity, the small white fleshy larvæ being seen with great distinctness on the black surface of the paper, affording satisfactory proof that this insect, the only one of the order at present known, is unquestionably ovo-viviparous, and will represent in future this peculiarity among the lepidoptera, similarly to those few species existing in the hemipterous and dipterous orders.

The Boston Natural History Society have had an account laid before them of the operations of the minute *Platygaster*, which attack the eggs of the *canker-worm moth* (Anisopteryx vernata). Mr. Scudder, the observer, states that after moving round a long while in search of a suitable place to lay its eggs, using its ovipositor as a feeler, the abdomen is plunged down into the space between three continuous eggs, and the ovipositor perforates one of them, out of view. The body of the insect assumes a position perpendicular to its exposed surfaces, supported in the rear by the wings, which, folded over the back, are placed against the surface behind, while the hind legs, spread widely apart, sustain the insect on either side, and the middle pair are placed nearer together in front. With the four legs dangling it remains motionless, except some slight movement of the antennæ, for three or four minutes, after which it moves off, seldom flying, in search of another place.

At a recent meeting of the Entomological Society a communication was read from the Lords Commissioners of the Admiralty, enclosing a copy of a circular letter from the Governor of St. Helena respecting the ravages committed in the island by the white ants. It was stated that they were (it was supposed) accidentally introduced from the coast of Guinea twenty years ago, and now almost every dwelling, shed, store in Jamestown, containing 4,000 inhabitants, have been seriously injured by them, involving in many instances complete ruin and abandonment, and imperilling the lives of large numbers of the poorer classes, who are still living in houses of doubtful security. The Governor was anxious for information as to the most successful mode of finding the ants' nests, and effectually destroying their receptacles, and as to the description of timber which had proved to be least susceptible of injury from the insects, and the average market price of such timber per cubic foot. General Sir John Hearsey stated that if ever ants effected a lodgment in the walls of a house, the walls themselves must be taken down before the insects could be eradicated. He thought the best preventive was to steep the timber before building in a solution of quicklime, and completely saturate it therewith; whilst store-boxes, furniture, and small articles should be painted over with a solution of corrosive sublimate. Mr. Bates coincided with General Hearsey in his estimate of the value of quicklime. The nests must be sought for in the plain. Mr. E. W. Robinson said that on the Indian railways creosote was applied to the sleepers—but it was not sufficient merely to coat them with the solution, but the whole block must be impregnated with the solution by hydraulic pressure.

Dr. J. D. MacDonald has communicated to the Royal Society of Edinburgh a memoir on the morphology of the tunicated mollusca, in which he considers that the fixed tunicates exhibit at least two well-marked types, and the free Pelagic group four, which are equally distinct and of equal importance. He also considers that very striking representative relationships exist between the fixed and free tunicates, as, for example, between *Appendicularia* and *Pelonaia,—Doliolum* and the remaining simple tunicata, Salpa representing the social, and Pyrosoma, the compound group, especially the Botryllians.

Professor Allman has just pointed out a curious and important character of the so-called nemataphores in the plumularian zoöphytes, hitherto unnoticed. In *Plumularia cristata* he finds them to consist of a true sarcode or protoplasm, and except in the fact that the protoplasm contains a cluster of thread cells immersed in its substance, it appears in no respect to differ from that which constitutes the substance of an amœba. This soft granular mass has the power of projecting extensile and mutable processes, consisting of a finely granular substance which undergoes perpetual change of form, comporting themselves in every respect like the pseudopodia of an amœba, which they also resemble in their structure, for they consist of a simple protoplasm composed of a transparent semifluid basis, in which minute corpuscles are suspended. In *Antennularia antenninia*, a genus possessing the closest affinities with *Plumularia*, entirely similar phenomena have been witnessed, the processes being usually simple, in only one instance there having been seen what appeared to be a short irregular branch given off from the finger-like pseudopodium.

M. Lacaze-Duthiers, who, we have observed, has obtained the Bourdin prize for his inquiry into the anatomy and physiology of corals, has produced a monograph of 371 pages, accompanied by another of 20 pages, comprising 120 figures relating solely to corals. He describes and draws in detail the reproductive organs, male and female, and has studied the development of the eggs, spermatozoids, and larvæ; has observed the larvæ during their period of liberty, determined the first signs of their future transformation, and followed this transformation step by step to the moment when the single being issuing from the single egg, begins to shoot, and gives birth successively to a whole colony, of which it is the actual parent. These facts are all new. Coral does not present the phenomena of *alternate generations*, established among so many other Radiata; still it enters none the less into the category of *geneagenetic* animals, as they are termed by M. de Quatrefages. The *scolex* alone undergoes a real metamorphosis. In general the sexes are distinct in corals, but one may occasionally find on a male stem a branch where the polyps are female, and *vice versâ*. A branch may also contain individuals of both sexes, and more rarely still the same individual may be both male and female. Thus, regarding the separation of the sexes, the coral zoöphytes present the two extremes and almost all the intermediate degrees.

M. Duthier's experiments are still in progress on the coast of Algeria, where he is endeavouring to determine the rapidity of growth of the coral, by immersing at a certain point 150 large jars marked so as to be recognizable, which, successively taken out, will furnish information on the development of the calcareous axis hitherto unknown.

The expedition led by the Rev. H. B. Tristiam for the scientific exploration of the Holy Land was early in January at Jericho investigating the natural products of the valley of the Jordan, which offered abundant promises of fruitful results. The preceding month had been spent in the more barren field of inquiry between Beyrout and Jerusalem. In the Jordan valley a new fauna was found to prevail, essentially different from that of the high land, and surpassing all previous expectations as regards its abundance, if not as regards its variety. The expedition proposes to pass the summer in the highlands of the Lebanon and surrounding district, and to return home in the autumn. The Government-grant committee of the Royal Society have recommended a grant of 50*l.* to Mr. Tristram in aid of the expedition.

A somewhat singular scientific expedition round the world has been organized by Austria. The *Marco Polo* was to leave Trieste on the 5th March, taking with her about 60 passengers, who were each to pay 400*l.* passage money, and the voyage was expected to extend over eight months. The actual voyage was calculated to occupy about 200 days, and 50 days were to be spent in visiting 30 different ports which had been selected as stopping places. The vessel has been fitted out with scientific apparatus of all kinds.

The French, not behindhand, are organizing an expedition to Mexico, which will probably be productive of useful results. This will be under the auspices of the Minister of Public Instruction, M. Duruy. He recommends that a sum of 8,000*l.* should be set apart to defray the expenses of the expedition, and his suggestions have been approved by an Imperial decree appointing the members of the commission. Among them are Marshal Vaillant, Baron Gros, Michel Chevalier, Vice-Admiral Jurien de la Gravière, Milne-Edwards, Baron Larrey and Viollet le Duc, M. de Quatrefages, &c.

REVIEWS.

THE STORY OF THE GUNS.*

WITH the din of war approaching nearer to our shores, and the political horizon assuming a more and more threatening aspect, it is no wonder that the 'Story of the Guns' should have been the book of the past quarter.

From the 'Natural History of Ceylon' to the subject under consideration is, indeed, a great leap, and there are few men living who could have accomplished it more easily than Sir James Emerson Tennent; but it would be alike unfair to our readers, and to the author himself, if we were to speak of this work in the same terms of unqualified praise as of his former labours. Whether it has been his intention, in the performance of what he may have conceived to be an imperative duty, to expose facts with which he considers that the nation should be made acquainted, namely, the extravagant and unwarranted expenditure of money upon an imperfect weapon, or whether it was simply his desire to reinstate in public favour a gentleman of rare abilities whom he believes to have been neglected and slighted by our Government, we are, of course, unable to say; but however honest may have been his intentions, we can assure him that he will have failed in creating the desired impression upon the minds of his careful readers.

A book emanating from such a source, and appearing at so opportune a period, could not fail to command attention, and the journals requiring literary extracts as a portion of their daily bread would necessarily increase its popularity and renown. But then come the thinkers, the men who read a work not with a view to ascertain what it says, but what it means; many of them, perhaps, with as strong a bias as the author himself, but in the opposite direction; and to these the book has been in a great measure a disappointment, for it is rather a story of the grievances of one gun manufacturer, and a disapproval of the favouritism shown to another (who received his appointment under a ministry professing political views which were until recently believed to be opposed to those of the author), than what it professes to be, namely, a history of our scientific progress in the manufacture of guns and rifles. And whilst we were toiling wearily through the narrative of Mr. Whitworth's wrongs and of Sir William Armstrong's unwarranted promotion, couched in language whereof it is difficult to say which of three qualities it best conceals—official caution, the pungency that characterizes the lower house, or the polite conventionality

* 'The Story of the Guns.' By Sir James Emerson Tennent, K.C.S., LL.D., F.R.S. Longmans.

of "another place,"—we could not help feeling that if ever a cause had been lost by too much pleading, it was in the case before us.

It matters not how true every alleged fact may be, there is from beginning to end of the work such a palpable *animus*, and the same statements and contrasts are so frequently reiterated to the prejudice of Sir William Armstrong, and dwelt upon so significantly, that a great portion of what should have given scientific interest to the work is completely cast into the shade by the political attack.

Having thus given expression to our discontent at the author's mode of treating this portion of his subject, and acting, as we believe, with more generosity than if we had retailed any of the episodes in the story of the *Gunmakers* which he has published, we proceed to glance rapidly over the contents of the volume. The first part of the work is devoted to the history of the musket and rifle, commencing with "Brown Bess," and closing with the triumph of the "Whitworth" over the "Enfield." Although, of course, the work refers rather to the past of the Enfield rifle than to its present state, it being described not as it is, but as it was, we have some very interesting comparisons between the early performances of the two weapons last named; and these have been illustrated very effectively by drawings of two targets, which exhibit the relative shooting made by the two rifles.

Let us mention, in passing, that we have seldom seen a work so admirably illustrated, the subjects for illustration being so well selected, and the execution so perfect, that explanations are hardly requisite, and a glance over the plates suffices to afford a good idea of the recent development in the fabrication of arms of offensive warfare. The bullet-marks on the Enfield rifle target are scattered about in every direction, many of them touching the very edges of the target, and very few approaching the centre; whilst in the Whitworth target, every mark is within one of the four central squares (there are in each target 20 shot-marks, and 42 squares), and many of them impinge upon the centre lines of the target.

From the consideration of small arms, the author passes, in his second Part, to that of ordnance, and here again we have a most interesting and graphic description of the various guns which have either had their hour and have passed away, or which are still in use here or elsewhere; amongst English rifled guns we have an account of the "Lancaster," "Whitworth," "Bashley Britten," "Lynall Thomas," "Jeffery," "Hadden," "Scott," and "Armstrong," with sections of all but the two first inserted on two opposite pages to exhibit their respective systems of rifling. Reference is made, too, to the French "*canons rayés*" and to the monster gun forged by the Mersey Steel Company at Liverpool. This gun weighs above 24 tons, and discharges a spherical ball 300 lbs. in weight; and some idea may be formed of its effect, by a reference to the frontispiece which represents the famous "Warrior Target," and exhibits the havoc made on it by this gun, as compared with the Whitworth. The remainder of the second part is taken up with the history of Sir William Armstrong, Mr. Whitworth, and their respective inventions; and we are told by the author that the mode of dealing adopted towards inventors by the State and the official appointment of Sir William Armstrong have rendered any considerable improvement in our offensive arms a matter of great difficulty. For although Sir William has resigned his appointment, and therefore leaves the Government free to deal with whom it likes, our author tells us that the outlay which has already been incurred "operates practically as a bond by which, under a penalty of two millions and-a-half sterling, the country is deterred from attempting any change." *

Before finally passing away from the question of the "contest," we will say that it leaves this impression upon the mind of a disinterested reader. One cannot help regretting that Sir William did not act more consistently after he had "made a gift" of his invention "to her Majesty and her successors without any pecuniary or other valuable consideration;" or that, instead of laying himself open to the imputation of having *given* his gun for a purpose, he did not require 50,000*l.* or 100,000*l.* for so great and valuable a safeguard to his country. But, on the other hand, when we are told that a man of known repute, who had been in constant communication with the Government, is suddenly thrust aside when his services are most needed and on a pressing emergency, and another comparatively unknown is preferred before him for a duty of immense responsibility, we cannot but feel that there must have been some shortcoming, some want of energy and promptitude, which caused his rival to be taken by the hand. Whether or not we have formed this opinion without a sufficient basis, our readers will have an opportunity of judging when we come to speak of more recent experiences than those referred to in the volume before us.

The Armstrong gun has been a very dear experiment, but it was rendered much more costly by the dispatch that was requisite in order to atone for the previous apathy of the Government; and it is impossible to say what dangers have been averted from our shores through the energy and promptitude of the man to whom the task of strengthening our means of defence was confided. Let us, therefore, not spurn the bridge that has carried us safely over our difficulties.

In speaking of the "Iron Navy" in the remaining portions of his work, the author tells us of the early failures of the most powerful guns to project a missile through the plated sides of a man-of-war. He refers to the valuable services of the Iron-plate committee, of whom one of the ablest and most useful members is Dr. William Fairbairn, of Manchester, and to the results attained through the experiments of that committee, the progress of the offensive and defensive art being traced to the time of his going to press.

Finally, he closes a work which, in spite of its serious defects, is destined to take its place amongst our standard books of reference in this branch of science (its tone and method frequently reminding us of the labours of the late respected minister of war, Sir George Lewis), with an admirable and scholarlike peroration, wherein he recommends the admittance of all deserving inventors into the ranks of competitors

* How much more is this, we would ask the author, than it cost us to *prepare* for the defence of Canada during the 'Trent' affair.

for the supply of arms to the State, and winds up with the patriotic declaration that "the abiding interests of the country will henceforth require that the man who reaches the high eminence of giving his name to the arms under whose protection the nation reposes, should hold it by no other tenure than that of uncontested superiority." And we trust the author will permit us to add, that the triumphant candidate may rest assured that his services will be as highly esteemed by the nation as are those of the man who, through the prompt application of an arm which he acknowledges to be imperfect, did much, at a period of pressing danger, to save his country from a serious infliction, and who at the present moment takes a very high rank amongst the scientific men of his country.

There are three conditions which our manufacturers of ordnance and of iron are endeavouring at present to fulfil, in order to secure a gun that will have a reasonable chance of success in action.

First, a sufficiently extensive range, with accuracy of aim; secondly, convenient proportions; and thirdly, a suitable projectile.

For an attack upon forts, especially where these are rendered unapproachable through natural or artificial obstacles, or *where the attack if made without due care, might involve the destruction of property or life which it would be desirable to spare*, the first condition is indispensable, and the author of the work we have just noticed tells us that Mr. Whitworth's rifled ordnance has carried off the palm in this respect, one of his 12-pounder guns having projected a shot nearly six miles. We believe that no new feature of importance has transpired in this respect since the work was published, and we therefore pass on to the consideration of the second and third objects.

Until very recently the greatest desideratum has been, and we believe at head-quarters it is still, to obtain a convenient "broadside gun" which can be easily managed in a heavy sea, and will do execution at between 200 and 2,000 yards against an enemy similarly armed and heavily plated. Such guns we have in our 68 and 110-pounders, and here again Sir James Tennent awards to Mr. Whitworth the credit of having constructed the *first* that could send a shot through armour-plate 4½ inches in thickness. This he effected with an 80-pounder gun, a charge of about 12 lbs. of powder, and a cylindrical bolt of "homogeneous metal," driving his shot at a range of 200 yards, through the armour-plate of the 'Trusty,' a vessel specially devoted to such experiments.*

But now we have a hint from the heads of the departments as to the cause of the want of co-operation between Mr. Whitworth and

* We are however informed by a good authority, that the first gun which ever penetrated a thick armour-plated target was made at Liverpool for the United States Government. This gun projected a missile which (in America) pierced a target plated to the thickness of 6 inches, and built up of ½-inch plates. The backing was 3 feet of solid oak, which the missile also penetrated, lodging in it so deeply that it was never recovered. The gun weighed 7 tons 17 cwt., with a bore of 12 inches, and carrying a spherical shot of 212 lbs. Mr. Whitworth's gun and the "Monster gun" were subsequently tried on the same day at Liverpool, and we believe that both were equally successful.

themselves. During a recent discussion in the House of Lords, the Earl of Hardwicke referred to this gun,* and recommended that such guns should be supplied to the service. The reply of the Duke of Somerset was that they had been anxious to have such guns, but that Mr. Whitworth was not able to deliver them, and subsequently Earl de Grey and Ripon informed the House that a committee was appointed in 1863, on which Sir William Armstrong and Mr. Whitworth were respectively represented; that the instructions of this committee were shown to both gentlemen, and that a certain number of guns was ordered from each competitor.

> "The guns so ordered were 12-pounders and 70-pounders. In a short time the 12-pounders were delivered, but Mr. Whitworth's 70-pounders had not been sent in yet, and from the time when it closed its evidence the committee had done nothing except repeatedly calling upon Mr. Whitworth to produce his 70-pounders. That was the reason why the inquiry had been stopped. Mr. Whitworth himself accounted for the delay by alleging the difficulties he experienced in getting the steel which he required."

The supporters of the gentleman last named maintained until recently that it was only a shot such as we have described, a flat-fronted cylindrical bolt of homogeneous metal, which would penetrate armour-plates of great thickness, and as far as the substance is concerned their views are pretty accurate. Indeed in the debate just referred to, the Duke of Somerset is reported to have said, that "if they fired with a cast-iron shot, the effect was trifling. Indeed they might almost as well fire mud at the target, unless the projectile was of a very hard substance." And he further told their lordships that "no sooner had they obtained a hard projectile than not only Mr. Whitworth's, but Sir William Armstrong's gun would fire a shot that would penetrate an iron plate."

He referred also to an experiment that had been tried a few days previously, and of which the details were published in 'The Times.' They prove most satisfactorily that the form of the shot is by no means so important a matter as it has been stated, provided the material be a suitable one, and that at close quarters an ordinary smooth-bore gun will answer every purpose.

Being the last experiment that has been tried at the time we write, we will give our readers an account of it, as received from an eminent and experienced eye-witness.

The trial was made in Portsmouth Harbour in the month of January, in the presence of many able scientific men, both civil and military, and the object aimed at was the side of the Target-ship, 'Monarch.' The gun was a plain muzzle-loading, smooth-bore 110-pounder, weighing six tons, and having a diameter of six inches throughout; in dimensions and outward appearance it resembled the old 68-pounder service gun (95 cwt.); it was made at Woolwich, and was called an 'Armstrong.' With a charge of 25 lbs. of powder it projected a spherical shot, weighing about 100 lbs., at 200 yards

* He called it a 70-pounder, but we presume it to be the same.

range, clean through a 4½-inch plate of good iron; and made such havoc in the ship's side, that the aperture was used by the sailors for ingress and egress as a porthole. The great secret, it appears, lay in the shot, which was manufactured by the Messrs. Firth of Sheffield. It was of cast-steel, estimated by our informant to have been worth about 80*l.* per ton; but he added that this would be quite immaterial, for one such shot would produce a more serious effect than a whole broadside from any of her Majesty's vessels. Of this more hereafter. A second experiment was tried with a round shot, made of Bessemer steel. This passed through a plate of 5½ inches thick (same range), but although the ship's timbers were much shattered, the ball did not pass through them, but lodged in them along with some pieces of plate.* With a case-hardened, wrought-iron shot the same effect was obtained against a 4½-inch plate as had been produced upon the 5½-inch plate in the experiment last referred to, showing therefore that the steel shot made at Sheffield deserved the most confidence, *and that that confidence has its money value.*

In fact the whole question appears to be one of pounds, shillings, and pence, and the more we consider it, the better satisfied are we that it is not yet the time to talk about economy; for our experience has still to be purchased, and the sooner we obtain it the better.

"The French frigates," says 'The Times' in a leader, "carry guns of very moderate weight and calibre, but these guns are rifled so as to have a long range, and are supplied with shot of a peculiar material for special use against iron plates. Our own 68-pounders have considerable power at close quarters, but no range; our 110-pounders have long range and great accuracy, but were not found effective against solid plates, except with a particular species of projectile. The actual state of things as regards our naval ordnance may be very briefly described. We have large guns which will send their shot through solid armour-plates, but these are too large for broadside guns, and can only be carried, therefore, in some fashion not yet naturalized in our navy. We have the 68 and 110-pounders above specified, and we have now also manufactured, but not yet issued, a smooth-bore 110-pounder capable of sustaining a charge of 25 lbs. or 30 lbs. of powder, and of piercing a 5½-inch plate. But this new piece, though making fair practice at 2,600 yards, has not the accuracy of a rifled cannon; and what we want therefore, but have not yet got, is a gun which shall combine the accuracy produced by rifling with the power required against solid armour." †

But there are other questions which press themselves upon the attention of those who consider the present transitional state of our armaments. If it be difficult to obtain "broadside" guns, but if, on the other hand, a single shot of a very expensive material may be fired from an ordinary gun, with the damaging effect of a "broadside," will not this last take its departure with the "wooden walls," and give

* This experiment was mentioned by his Grace the Duke of Somerset, but our informant seems to regard it as the less successful of the two, as the ball lodged in the backing. It is necessary to watch these experiments carefully, for here we have not only rival gunmakers, but also rival steel manufacturers.

† We do not know whence 'The Times' derives these particulars, nor what particular gun is referred to.

place to three or four heavy cannons, which will do the work with more effect at a greater range? To this subject a reference was recently made by a correspondent in 'The Times,' and when duly weighed it appears most important. In addition to doing the work more effectively at the least cost in the long run (for, of course, fewer guns will require, proportionately, less men), we have the fact that such a change, by lightening the weight of the equipment, *would admit of the application of a heavier armature*, and there would thus be gained a more powerful means of attack, a more obstinate resisting medium, less expenditure of money, and less waste of life.

For, after all, it is our military engineers who should have these latter objects in view in all their schemes of offence and defence. Although we are not members of the Peace Society, we sympathize with those who are constantly laying stress upon the fact, that war is not only a bloody, but a costly game; a game which will only be played out when the belligerents discover that the stakes, in every case, amount to more than the prizes. Duelling has ceased to be the fashion, because less courage and dexterity are required to put a ball into the body of a man, at 100 yards, than to pierce him through with a rapier; and as war becomes more mechanical, and the cost is increased, whilst the occasions for the display of prowess become less frequent; when man finds that it is no longer a question of the strongest arm, but of the toughest steel—then he will begin to open his eyes to the fact that he is not a fighting, but a reasoning creature; and that if the Almighty had meant to make him resemble a tiger, intending that he should settle his differences by brute force, He would have furnished him with claws, and with a much smaller and less convoluted brain than that of which he now stands possessed.

THE INDUSTRIAL RESOURCES OF THE NORTH COUNTRY.*

It is always of interest to note the onward march of human industry—to see man advancing from point to point, subduing nature, and making each conquest a standing place upon which to apply his knowledge.

Upon this ground, especially, are we pleased with the handsome volume which has been issued under the auspices of some eminent members of the Coal-trade of Newcastle, and of the Institute of Mining Engineers, informing us of the Industrial resources of the Tyne, Wear,

* 'The Industrial Resources of the District of the Three Northern Rivers—the Tyne, Wear, and Tees,' &c. Edited by Sir William Armstrong, J. Lowthian Bell, Esq., J. Taylor, Esq., and Dr. Richardson. Longman, London; Reid, Newcastle.

'A History of the Trade and Manufactures of the Tyne, Wear, and Tees,' &c. Second Edition. Spon, London; Lambert, Newcastle.

'A Handbook to Newcastle-on-Tyne.' By the Rev. J. Collingwood Bruce, LL.D., F.S.A. Longman, London; Reid, Newcastle.

and Tees. This title, indeed, scarcely expresses the real character of the volume. It is rather an account of the present state of man's industry upon the banks of those rivers, and an indication of resources which are yet to be made available. Three rivers rising amidst the varied scenery of the Mountain-Limestone-hills of Durham, Cumberland, and Northumberland have gathered upon their margins some of the most remarkable evidences of man's power which this country can present to the inquirer; and of these, the several writers, who have contributed to these volumes, have endeavoured to furnish genuine information.

The two works which stand first on our list are almost the same in matter. The first appears as a handsome royal octavo volume, with excellent maps, sections, and plates. The second is very humble in its appearance, and has neither maps nor plates. Both are, however, reprints of the address delivered by Sir William Armstrong, and of certain papers read before the different sections of the British Association, "revised and corrected by the writers." In the first, these papers take the form of special reports; in the second, they are given as isolated papers, and the larger and illustrated volume adds important "Reports on the Improvements introduced in the Rivers of the District."

The little volume which stands last on our list, is one of the most complete "Handbooks" which has ever fallen into our hands. Its archæological and descriptive division being the work of a man eminent in that department of knowledge, while the portion devoted to the manufactures of Newcastle has been produced by the mayor of that town, who, by his vocation and special knowledge, is peculiarly fitted for the task.

With this notice of the general character of these books we leave them, except in as far as they aid in obtaining a correct knowledge of the present state and of the prospects of those industries which come under notice.

The present annual produce of coal from the Great Northern coal-field is given by the reporters at 21,777,570 tons. This is somewhat in excess of the quantity given in the "Mineral Statistics of the United Kingdom." The vend of coals both Coastwise and Foreign, was, in 1791, 2,079,605, which advanced in 1862 to 10,134,790 tons; the remainder having been consumed in the manufactures, railways, and mines, and for domestic purposes at home.

With this great drain upon a limited area, the question raised by Sir William Armstrong, of the duration of the supply, becomes a most important one. In our last number, however, we gave this subject sufficient attention. The engineering of coal-mining is clearly treated of. Boring, coal-cutting, coal-washing, ventilation, and lighting coming under notice. The coal-cutting machine of Donesthorpe and Co. is especially noticed; and the reporters say:—"We shall thus be enabled to work profitably seams of coal varying from one foot six inches, to two feet in height, or even lower, and thus vastly prolong the duration of the coal-field." This view was not embraced in our notice of the coal-cutting machines in our last number.

We could have desired a more extended notice of Coke manufacture than that which has been given.

The paper on Iron, by Mr. J. Lowthian Bell, is a most important one, and to the date of its production it may be said to have exhausted the subject, forming, as it were, the balanced ledger of the ironmaster. From this paper we learn the production of Pig Iron, for three years, to have been:—

	1860. Tons.	1861. Tons.	1862. Tons.
Northumberland	69,093	73,260	46,586
Durham	340,921	312,030	337,218
Yorkshire—North Riding . . .	248,665	234,656	283,398
	658,679	629,946	667,202

There were 646 puddling furnaces in action. "The united power of all these works will be equal to an annual production of 340,000 tons, and probably the actual make during the year 1862 may have amounted to 300,000 tons." The manufacture of steel is treated of in a very brief paper by Mr. Spencer.

The local manufactures of lead, copper, zinc, antimony, &c., have been treated of by Mr. Sopwith and Dr. Richardson. Mr. Sopwith has naturally dealt with the lead mines of the district, and given a concise account of Alston Moor, Weardale, and Teesdale. In 1862 the Cumberland division gave 5,241 tons of lead, and 41,911 ounces of silver; Durham and Northumberland giving 16,454 tons of lead, and 82,854 ounces of silver.

The copper ore raised in those counties is very small, but some copper is obtained from the sulphur ores (Iron Pyrites) which are employed in the manufacture of sulphuric acid. Zinc is obtained in small quantity. The ores of antimony are all imported. In addition to these papers, Mr. J. Lowthian Bell has given a notice of the manufacture of aluminium, this paper concluding the series devoted to the production of the metals.

The Chemical manufactures of the district have been described by Dr. Richardson, Mr. J. C. Stevenson, and Mr. R. Calvert Clapham. The total value of the products of these industries is stated to be 145,520*l.* sterling.

As an Appendix to this, we have a note on the recent discovery of Salt at Middlesbro'. Messrs. Bolchow and Vaughan being anxious to obtain a supply of fresh water for their iron works, commenced, about four years ago, to sink a shaft for this purpose. This well did not answer their expectations, and a very large bore-hole was put down from the bottom of the shaft. The strata passed through are in the upper New Red Sandstone, or the same in which the Cheshire rock-salt is found. In August, the depth attained was 217 fathoms—the last 100 feet being through a bed of salt—at the bottom of which they had not at that time arrived. It is impossible to overrate the importance of such a discovery to this district, where the consumption exceeds 100,000 tons per annum.

Clay wares and glass are manufactures which have been long established on the Tyne. They are succinctly described, and the annual value stated to be as follows :—

	£
Glass	638,000
Earthenware	190,000
Fire-clay Goods	228,650
	£1,066,650

The manufactures of Paper and Leather are briefly reported on; but more important are the papers on "The Construction of Iron Ships," by Charles H. Palmer; and on "The Engineering Manufactures," by P. Westmacott, C.E., and J. F. Spencer.

Valuable Appendices introduce us to Sir W. Armstrong, who clearly describes the construction of Wrought-iron Rifled Field-guns; and to Mr. John F. Tone, C.E., who takes charge of "Railways and Locomotives."

The improvements now being carried out on the rivers Tyne and Tees are described by Messrs. Ure and Fowler with much precision.

From this notice of these volumes, it will be seen that a large amount of energy is expended upon the natural advantages of this important Northern Coal-field, from which we may expect yet more gigantic results. Sir William Armstrong well says—"The tendency of progress is to quicken progress, because every acquisition in science is so much vantage ground for fresh attainment. We may expect, therefore, to increase our speed as we struggle forward; but, however high we climb in pursuit of knowledge, we shall still see lights above us, and the more extended our view, the more conscious we shall be of the immensity which lies beyond."

QUALITATIVE CHEMICAL ANALYSIS.*

THIS book has been long and favourably known to the British public. It is *par excellence* the standard work upon the subject of which it treats; the system of instruction is that which first met with general adoption in this country by the student in analysis, and the successive improvements in chemical methods and research have from time to time been duly chronicled; so that in the edition just now published we have at once a full and satisfactory account of all that is known on the subject. By the insertion of a large amount of new matter the dimensions of the volume have been greatly augmented, the present edition having been expanded to 350 pages, and in comparing this with former editions it is manifest that the introduction of the new system of spectrum analysis has added much to the impor-

* 'A System of Instruction in Qualitative Chemical Analysis. By Dr. C. Remigius Fresenius. Edited by J. Lloyd Bullock, F.C.S.' Sixth Edition, 1864. London: John Churchill and Sons, New Burlington Street.

tance of the work. A noteworthy addition is the beautifully coloured frontispiece illustrative of the more characteristic spectra among the metallic elements. It is much to be regretted that the position of the single green ray of thallium is not indicated in the spectrum chart; but, as though to compensate in some measure for this omission, a remarkably good account of the new metal and its principal reactions will be found in the chapter on thallium. The most approved forms of spectrum apparatus, particularly those devised by MM. Kirchhoff and Bunsen, are here fully described and illustrated by woodcuts. The chapter on apparatus generally has received important additions; we may mention especially the very useful instrument recently invented by Professor Graham, and known by name as the 'Dialyser.' The application of this instrument in the detection of poisons, and the important aid it is likely to render in toxicological examinations by affording a simple means of extracting the poisonous principles from the host of heterogenous organic matters with which they are commonly associated, are treated of at length and in a manner suitable to the growing importance of the subject. Special instructions are laid down for the recognition of the vegeto-alkaloids,—a class of bodies which are becoming daily of more extended use as remedial agents and therefore of more frequent occurrence as objects of chemical study,—and a chapter is devoted to a systematic course to be followed in the detection of unoxidized phosphorus, hydrocyanic acid, arsenic, strychnine, &c. In short, as a treatise on toxicology, 'Fresenius' Analysis' can be confidently recommended: and in this connection the numerous illustrations of apparatus employed in the detection of these poisons cannot fail to be highly suggestive to the analyst engaged in medico-legal inquiries.

The leading characters of the rarer metals, *e.g.* cæsium, rubidium, thorium, cerium, lanthanum, didymium, and even erbium and terbium, are pointed out under their respective analytical groups, and these particulars are printed in small type to denote their minor importance. In consequence of the foreign origin of this work there are one or two trifling instances of departure from the ordinary nomenclature to be observed, thus, the earth glucina is described as "berylla," and the metal tungsten has received the appellation "Wolframium." The chemical symbols Be and W partly sanction the employment of these names, but by the same rule, the common potash and soda would become *kalia* and *natria.*

The system of analysis adopted throughout is that which has received the sanction of the highest authorities both in this country and abroad; the methods of separation are extended occasionally by the necessity for giving the several approved modes for effecting the object, where the attainment of absolute success is a matter of some difficulty, and even now we are disposed to question the accuracy of the processes recommended for the separation of antimony, tin, and arsenic.

In the body of the work are given full directions for the analytical examination of plant-ashes, agricultural soils, and mineral waters; much of the information upon these points remains substantially identical with former editions. We notice particularly that the organic constituents of drinking waters continue to be described under the indefinite titles of "crenic and apocrenic acids." The use of these terms cannot be considered satisfactory at a time when they are never employed in chemical reports. It must be admitted, however, that the identification of dissolved organic matters, and the determination of their amount by quantitative analysis, are still far from satisfactory, and constitute subjects urgently requiring further chemical research. Again, in the preparation of vegetable ashes for the purpose of identifying and determining the mineral constituents of the plant it would be good policy to abstain in all cases from applying such a degree of heat as will be required from the complete incineration of the organic structure, inasmuch as the employment of so elevated a temperature is sure to induce the loss by volatilization of a certain proportion of the alkaline salts. A more judicious course consists in using no greater heat than is required for the complete charring of the organic matter, then to extract with water in order to remove the soluble salts, and afterwards dry and burn the carbonaceous residue for the purpose of recovering the remainder of the mineral salts.

The work is remarkably well printed, and free from errata. The mode of division into chapters and paragraphs, distinctly numbered, facilitates reference; and there is much satisfaction in being informed of the authority upon which a statement is made, and the name has been generally given between parentheses. A very useful table of weights and measures concludes the volume. There are some repetitions to be noticed in the analytical details prescribed for the examination of simple and of complex substances; but these are only such as could not be entirely avoided in a work devoted to instruction. Altogether, we feel strongly disposed to recommend this treatise to the favourable notice of the student in chemical analysis; and must remark, in conclusion, that the sixth edition fully maintains the high character of a standard work which "Fresenius' Analysis" has so long enjoyed.

PAMPHLETS.

The Power of God in His Animal Creation. By Professor R. Owen, D.C.L., F.R.S. Nisbet.*

It is not always the iconoclast who renders the greatest services to his fellow-men. Much as we may admire the courage of the man who steps forth boldly from the crowd, and under the conviction that the idol which it adores must be broken in order to show its impotence, shatters it to fragments; we have still more faith in him who quietly leads the terrified worshippers up to the stone image, and seeking to soothe their apprehensions, satisfies them by the touch that it possesses no life, nor yet the power to injure or befriend them. Errors inculcated during long ages may be shaken for an instant, but they cannot be eradicated by a *coup d'état*, and it often happens that a gentle and well-timed remonstrance has a more lasting influence upon the minds of men than the loudest, though they may be the most rightful denunciations.

We have before us an illustration of this fact in the delivery of the present lecture to the Young Men's Christian Association, in which Professor Owen has not only rendered an important service to science, but has displayed great moral courage in planting the banner of progress and free discussion upon the walls of a fortress that few younger men would have ventured to storm. In direct opposition to the preconceived views entertained by the large majority of his hearers on theological subjects, he stated firmly, but temperately, the results of modern scientific research, most widely at variance with the tenets of many orthodox theologians, and gave additional force to his uncompromising assertions, by selecting only those topics which are no longer open to debate.

The vast assemblage of his hearers, lay and clerical, men and women of every age and temper, would be nearly unanimous in the belief that the world is about 6,000 years old, and that the whole fabric, with its living denizens, was formed perfect in seven days of twenty-four hours; but he told them that the researches of science have led to the certainty that such a period is utterly, "nay, absurdly inadequate," for the Divine operations as they are conducted, to have prepared and peopled the dry land.

He assured them further, that instead of physical death having come into the world with the "fall," "life has been enjoyed during the same countless thousand of years; and that with life, from its beginning, has been death." And by means of a diagram, showing the geological and palæontological history of the past, with the traces of man, osseous and archæological (if we may so call them), he exhibited to them the indisputable evidence of his great antiquity.

And should even the Darwinian theory of the natural selection of new

* A Lecture delivered in Exeter Hall before the Young Men's Christian Association.

species through secondary agencies ever come to be an acknowledged law, Professer Owen will have done much to prepare these young men for its reception, for after showing them that the Creator has brought all his works to perfection by a gradual development, he told them that "just as death is met by birth, so extinction has been balanced by creation, that is, a constant and continuous operation of Creative Power, which has produced a succession of species;" also, that "we discern no evidence of pause or intermission in the creation or coming to be of new species of plants and animals." And lest there should be any mistake as to his meaning, he repeats his belief in "the world's vast age, and in the unintermittence of creative acts," notwithstanding that such views may be regarded by some of his hearers with "abhorrence." Professor Owen hoped, however, that there were no such prejudiced persons in his auditory.

Nor did he confine his admonitions to his lay hearers. He spoke to the clerical portion of his audience of the futility of attempting, to put a literal interpretation upon symbolic texts in Scripture, as though they were statements of matter-of-fact. His illustration he drew from the supposed erect attitude of the serpent before the temptation of Eve, explaining that, instead of being the "progeny of a transmitted species, degraded from its original form as the penal consequence of its instrumentality in the temptation of Eve," the structure and organization of these animals are specially adapted to their position and habits, being replete with "instances of design in relation to the needs of their apodal vermiform character." And he reminded his clerical friends of the opposition interposed in the way of progress by the priesthood of old, repeating the admonition of St. Augustine, that men *will* believe the earth to be rotund, and should they preach it to be flat and denounce the new doctrine, they will say, "If ye know so little of earthly things, how shall we believe you when you tell us of heavenly ones?"

There need be no apprehensions for Christianity under the new regime, he said, inasmuch as it has suffered nothing since physical doctrines "declared contrary to Holy Writ" have been established; and he concluded his address as follows:—"Allay, then, your fears and trust in the Author of all truth, who has decreed that it shall never perish; who has given to man a power to acquire that most precious of his possessions with an intellectual nature that will ultimately rest upon due demonstrative evidence."

Some may think that the lecture is marred by the too frequent introduction of Scripture texts and quotations; but, on the whole, it is a noble address, and the Committee of the Young Men's Christian Association have studied their own interests in giving it a large and unrestricted circulation.

THE NEGRO'S PLACE IN NATURE. By James Hunt, Ph.D., &c. Trübner and Co.

IN the Introduction to this 'Journal' we referred to a paper on the above subject, read before the members of the British Association; and this is now published, the author tells us, by the general wish of the Fellows of the Anthropological Society, of which he is the president.

We ventured, in speaking of the original paper, to differ from the views of the author, which we believe to be contrary to the evidence and at variance with the opinions of the most advanced physiologists of the day, and drew attention to the fact that the most important question of hybridity had been almost completely ignored, and that what little was said of it ran counter to the author's doctrine of a specific difference between the white man and the Negro. We also mentioned, in passing, that a Newcastle journal did not hesitate to hint broadly that the gentlemen who thus sought to degrade the Negro race (for the president found a warm supporter in his secretary, Mr. Carter Blake) were the tools of the Southern confederacy, and that their services had been enlisted as the champions of slavery in England.

In adopting the supposition of the Newcastle paper, we confess that we were guilty of indiscretion, and we have to apologize to the shrewd and discerning politicians who administer the affairs of the Southern Confederacy, for having supposed them capable of adding to the indiscretion of attempting to found their new empire upon the basis of slavery, by using such an instrument as this for the purpose of obtaining sympathy in England.

No! Great as may be the fatuity of the Southern people on the question of slavery, they would never have attempted thus to "inoculate" us, the "outer barbarians," as the author has it in his dedication to "My dear Burton;" and we are now prepared to accept his statement concerning the object of his paper, as perfectly original and emanating from himself alone,—*viz.* that when the truth comes out, "the public will have their eyes opened, and will see in its true dimensions that gigantic imposture known by the name of 'Negro Emancipation.'"

But we must treat our readers with an extract from the work, in order that they may judge of the kind of material with which it is intended to explode this "gigantic imposture," and they will at once have an opportunity of judging of its science and its *morale :*—

"But while the analysis of a single bone or of a single feature of the Negro is thus sufficient to demonstrate the specific character, or to show the diversity of race, that great fact is still more obviously and with equal certainty revealed in the form, attitude, and other external qualities. *The Negro is incapable of an erect or direct perpendicular posture.* The general structure of his limbs, the form of the pelvis, the spine, the way the head is set on the shoulders, in short, the *tout ensemble* of the anatomical formation forbids an erect position. But while the whole structure is thus adapted to a slightly stooping posture, the head would seem to be the most important agency; for with any other head, or the head of any other race, it would be impossible to retain an upright position at all. But with the broad forehead and small cerebellum of the white man, it is perfectly obvious that the Negro would no longer possess a centre of gravity; and therefore, those philanthropic people who would 'educate' him into intellectual equality, or change the mental organism of the Negro, *would simply render him incapable of standing on his feet, or of an upright position on any terms.*"*

We presume it will not be necessary for us to refute the assertions (adopted by the author as evidence of the specific difference between the Negro and the white man), that the Negro is "*incapable* of an erect or perpendicular position," and that education would "*render him* incapable of standing on his feet, *or of an upright position*"!

The kings of Western Equatorial Africa, we are told, are under the necessity of encouraging the slave trade, in order to get rid of their criminals.

"No one, we presume, will dare assert that there are no criminals in Africa! What shall we do with our criminals? may be a problem which is occupying the attention of the political economist of Africa—like His Majesty the King of Dahomey—as well as the government of Great Britain. Is Africa not to be allowed to export her criminals, or are they so worthless and unmanageable that no people will have them?"

But it must not be supposed that the author advocates the slave-trade. Oh dear, no! He "protests against being put forward to advocate such views." "Our Bristol and Liverpool merchants," he says, "perhaps, helped to benefit the race when they transplanted some of them to America, and our mistaken Legislature *has* done the Negro *race*"—(why not species?—merely the force of habit, we presume)—"much injury by *their*† absurd and unwarrantable attempts to prevent Africa from *exporting* her worthless or surplus population." We have done; and if, after these extracts, our readers feel any desire to know more of the work, they must purchase it; for, although it is a tract such as we are ashamed to see printed in the English language, it has found a respectable publisher.

The Batavian Society of Experimental Philosophy in Rotterdam.‡

We desire to draw the attention of our leading Literary and Philosophical Societies to the plan adopted by the body of savants to whose prospectus we are about to refer, for encouraging the study of practical science, and would recommend it to their consideration whether a similar method of awarding premiums for careful research would not add much to their usefulness and success.

* The author is here quoting a Dr. Van Evrie of New York. The italics are ours.

† We again claim the italics; the grammar is the author's.

‡ The Society's 'Programme,' issued in December, 1863. Imprimerie de G. and C. A. Van Reyn, Rotterdam.

It is indeed seldom that we have read the programme of any institution with so much gratification as this one; it is as concise as it is interesting, and the only objection we have to the Society is its name, for it would convey a better idea of its operations if it called itself a practical, instead of an "experimental," institution.

The Council awards three prizes annually: a gold and silver medal, and a premium varying in amount from 50 to 150 florins,—a total therefore of 30*l.* or 40*l.*, which would be no serious outlay for any of our leading metropolitan or provincial scientific institutions.

As to the questions propounded, we shall convey the best idea of their character, and at the same time give the most practical effect to our suggestion, by translating and inserting a few of them in these pages.

Question 106. (Evidently intended for sailors.)—"The Society believing that an investigation of the temperature of the water in extensive seas, and at considerable depths, would be of great importance for ascertaining the physical state of our globe; and feeling satisfied that on board many vessels this temperature may under favourable circumstances be determined; desire to receive accurate researches on the subject, undertaken (with the employment of proper nautical instruments for ascertaining the latitude and longitude) in places where such experiments have not yet been made. The results must be stated succinctly, and in a careful detailed manner."

Question 114.—"For many years past scientific men have debated the possibility of constructing, on the seaboard, harbours of refuge for vessels with a deep draught of water, similar to those found on the northern and southern coasts of Holland. It has been asserted that, with the progress made in science, the construction of such harbours no longer offers any difficulties."

The Society therefore requires the complete plan of a harbour upon a coast such as, for example, Schevening, which would admit, at low tide, vessels drawing 23 feet of water" (7 metres), "and having an entrance wide enough to allow such vessels to cast anchor inside, with a violent gale blowing from the NE. The cost of construction and annual maintenance is also required."

Question 135.—"It is important that persons engaged in the study of electricity should make themselves acquainted with the phenomena produced upon telegraph wires by storms and by the Aurora borealis. Many of these phenomena are very partially understood, and it is desirable that more extended experiments should be communicated, from which it would be possible to make deductions."

Question 137.—"Mr. Tyndall believes his experiments have proved beyond a doubt that the vapour of water" (a moist atmosphere) "exercises a more powerful absorbent influence upon radiant heat than dry atmospheric air. Mr. Magnus, on the other hand, considers himself justified in concluding from *his* experiments that there is no difference in the absorbent property of a dry and of a humid atmosphere. The Society would wish to see these conflicting views met by conclusive experiments."

Our limited space will not admit of the insertion of more of these questions, but we may state that they are all of more or less general interest, and that the large majority are practically useful. Some deal with local improvements; others, with the statistics of the country; and others, again, require investigations in the various branches of Physical and Mechanical Science, in Crystallography, Geology, Chemistry, Botany, Physiology, &c.

The replies of competitors, which are expected to take the form of short essays, may be indited in the Dutch, French, English, German, or Latin languages, and as far as we are enabled to judge from the precautions taken to ensure impartiality to all candidates, and secrecy to unsuccessful ones, we should say that students are justified in placing their labours in the hands of the Society in perfect confidence that they will receive fair treatment.

As we have already observed, we hope that some move will be made in this practical direction amongst our English Institutions; the Society of Arts already awards such prizes, but there is no reason why every important "Philosophical" Society should not do the same, and we shall be glad to receive more of these programmes from other countries, in order to extract from them any new features in their management, for the benefit of our English readers.

Spectrum Analysis.

Those of our readers who may be able to read the Dutch language, will find in it one of the best works yet published on Spectrum Analysis.* The book is so good that it deserves translation into a language that would ensure it a wider circulation; and as we are in want of such a work in England, we commend it to the notice of any good Dutch scholar and chemist. Tracing the art from its first origin, the author brings down his account of the successive discoveries to the latest published observations of Bunsen, Kirchoff, and Miller, describing most of the observed spectra, and giving what will be found extremely useful to many—a very complete bibliography of the subject. The work is accompanied by some beautifully-executed coloured drawings of various spectra.

One of the earliest applications of the prism to chemical analysis was that of Plucker, who observed the lines produced by the passage of electricity through a rarefied gas, and noticed that in every gas, when pure, a particular system of lines was obtained. The minute portion of a gas, whether simple or compound, that could be analysed in this way induced the author to style the method *microchemistry*. It was really spectrum-analysis. M. Morren followed up the researches of Plucker, and now publishes at Marseilles a tract,† the object of which, he says, is to point out how this mode of analysis may help to solve

* De Spectraal-Analyse &c.'—On Spectrum Analysis, &c. By H. C. Dibbits. Rotterdam: E. H. Tassemeijer. 1863.

† 'Des Phénomènes Lumineux que présentent quelques Flammes, et en particulier celle du Cyanogène, et de l'Acetylène, &c.' Par M. Morren. Marseilles: Arnaud & Co., 1863.

questions which ordinary chemical processes are unable to unriddle. What, for example, constitutes the blue part of the flame of a candle? The spectroscope answers, vapour of carbon. The author once thought that the blue was caused by light carburetted-hydrogen, since he observed the same spectrum from the flame of this gas, and also from that of the base of a candle flame. A perusal of Dr. Attfield's paper on the "Spectrum of Carbon," however, induced him to reconsider the subject, and to examine the spectra of numerous other carbon compounds. In all these he observed the same spectrum, which, being common to everyone, must have been derived from the common constituent, carbon. The means which the author employed, and the appearances he observed, are well described in this tract; and any experimenters working in the same direction would do well to consult it.

Chemical Formulæ.

Dr. Odling has published* a set of tables of chemical formulæ, which we venture to say will prove as useful to teachers as to students of chemistry. He adopts an original mode of classifying the elements which is, perhaps, as reasonable as any other yet proposed, or possible, in the present state of our knowledge of these bodies.

The formulæ are all constructed on the unitary system of notation, and in the absence of a complete work of chemistry based on that system, these tables will prove of great assistance to students, who are obliged to read a book written upon the old system, and listen to a lecturer who teaches upon the new.

Lecturers who are beginning to teach the unitary system, will find in the tables the materials of a very useful set of diagrams.

* 'Tables of Chemical Formulæ,' arranged by W. Odling, M.B., F.R.S., &c., &c. London: Taylor and Francis, 1864.

NOTES AND CORRESPONDENCE.

Silvered Glass Telescopes and Celestial Photography in America. By Professor Henry Draper, M.D., New York University.

New York, *Feb.* 2, 1864.

The first photographs of the moon were taken in 1840 by my father, Professor John W. Draper, M.D., who published notices of them in his quarto work, 'On the Forces that Organize Plants,' and in the 'Philosophical Magazine.' The specimens were about an inch in diameter, and were presented to the Lyceum of Natural History of New York. They were made by means of a lens of five inches aperture, furnished with an eye-piece to increase the magnifying power, and mounted on a polar axis driven by a clock. At that time it was generally supposed that the moon's light contained no actinic rays, and was entirely without effect on the sensitive silver compounds used in daguerreotyping.

In 1850, Mr. Bond made use of the Cambridge (Massachusetts) refractor of 15 inches' aperture, to produce daguerreotype impressions of our satellite, the sensitive plate being placed at the focus of the object-glass, without the intervention of an eyepiece. Pictures two inches in diameter were thus produced, and, subsequently, some of the same size were made on glass, and mounted stereoscopically. Mr. Bond also made a series of experiments to determine whether photography could be advantageously applied to the measurement of double stars, and concluded that the results were as reliable as those derived from the micrometer.*

Soon after, Mr. Warren De La Rue, of Cranford, near London, undertook by the aid of a 13-inch speculum, ground and polished by himself, to procure a series of photographs of the moon and other celestial objects. The excellent results that he has obtained, together with those of Professor Phillips, Mr. Hartnup, Mr. Crookes, Father Secchi, and other physicists, are doubtless familiar to all scientific men, having been published in the form of a report to the British Association in 1859. No detailed description of them is necessary, therefore, in this place.

In 1857 Mr. Lewis M. Rutherfurd, of New York, erected an equatorial refractor of 11 inches' aperture, the object-glass of which he had himself corrected, and has taken a large number of lunar photographs with it. They have generally borne to be magnified to five inches, and he is now engaged in perfecting a correcting lens that will allow still greater enlargement to be used.

The moon, as seen by the naked eye, is about one-tenth of an inch in diameter, although persons generally estimate it at 10 inches. That the first statement is true is easily proved either by taking a photograph with a lens of 10 inches' focal length, or more convincingly by holding up between the moon and the eye a little disc one-tenth of an inch across, at the nearest distance of distinct vision (10 inches). A picture of the moon of the size commonly attributed to her requires to be made under a power of 100 times.

In 1857 I visited Lord Rosse's great reflecting telescopes at Parsonstown, and had an opportunity of not only seeing the grinding and polishing operation by which they were produced, but also of observing some stars through the six-foot instrument. On returning home in 1858 it was determined to construct a large instrument by similar means, and devote it especially to celestial photography. The speculum was of

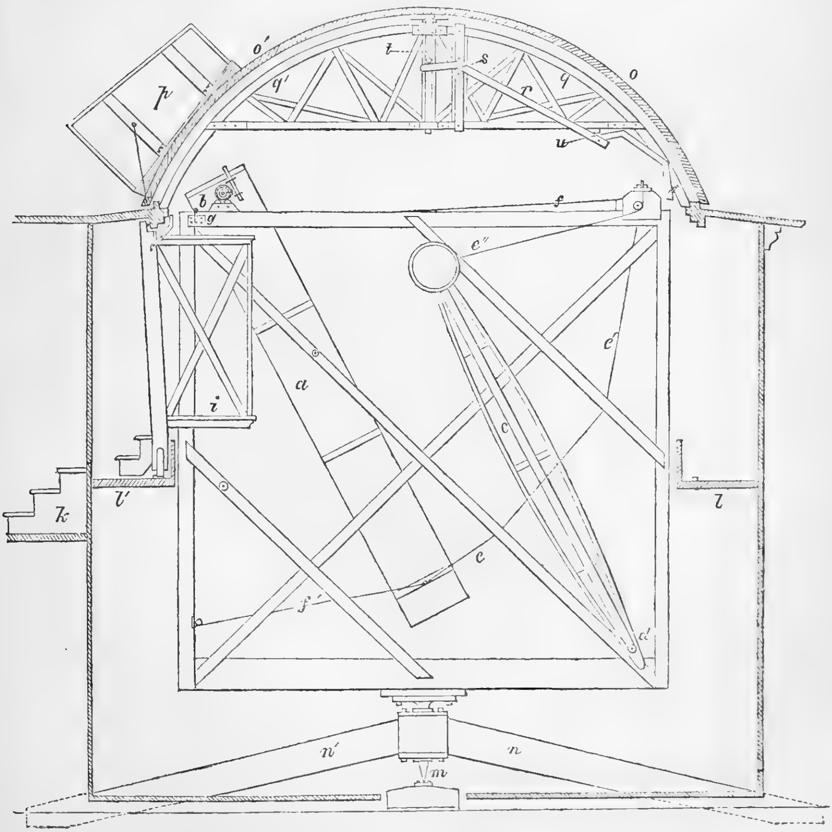
* 'Astron. Nach,' No. 1129.

15 inches' aperture, and 12 feet focal length. Subsequently, however, this metal mirror was abandoned, and silvered glass, as suggested by M. Foucault, substituted. This latter, according to Steinheil's experiments, reflects more than 90 per cent. of the light falling upon it, while speculum metal only returns 63 per cent. A detailed account of this instrument, amply illustrated, is now being published by the Smithsonian Institution at Washington, and therefore only a general idea of its peculiarities will be given.

As the telescope was intended especially for photography, the following general principles were adopted. 1st. A reflector was, of course, preferred to an achromatic object-glass, because all the rays falling upon it are reflected to the same focal plane, and there is not, as in the latter, one focus for distinct vision, and another for the photographically actinic rays, an inch distant perhaps. In the reflector a sensitive plate put where the image is seen to be most sharply defined, will be sure to give a good result. In the achromatic, on the contrary, the sensitive plate must be placed in a position which can only be found by tedious trials. 2nd. Silvered glass was used instead of speculum metal, because it is lighter and more highly reflecting. Besides, if a reddish or yellowish film should accumulate on it—an accident liable to occur to either kind of reflector and seriously diminishing the photographic power—it can either be repolished with a piece of buckskin—an operation obviously impossible in the case of a speculum metal—or the silver can be dissolved off with nitric acid, and a new film deposited on the glass concave. The glass which has been made accurately parabolic before the first silvering, is not changed in figure, the silver being only deposited in a layer $\frac{1}{200000}$ of an inch thick, and consequently, if carefully prepared, copying the glass below so closely that no error larger than a small fraction of that amount is possible. As the glass only serves as a basis or mould for the thin sheet of silver, and is not penetrated by the light, its quality is a matter of but little moment, that which is used for skylights or light-openings in floors answering perfectly. 3rd. A mounting, presenting the greatest degree of steadiness possible was necessary. For this purpose the telescope was supported at both ends, the lower one resting in a loop of wire rope. 4th. Instead of driving the whole mass of the instrument by clockwork acting upon a polar axis, and thus being forced to move a weight of at least half-a-ton—the usual system in equatorials — only the sensitive plate and its frame, weighing an ounce, were caused to follow the moon or other object, the mass of the apparatus remaining perfectly at rest. This idea is due to Lord Rosse. 5th. Instead of using a clock with wheelwork for a prime mover, a *clepsydra* was substituted. This consists of a heavy weight supported by the rod of a piston, which fits into a cylinder filled with water. At the bottom of the cylinder a stopcock permits the water to flow out at a variable speed, depending on the amount of opening. The sensitive plate can thus easily be caused to coincide in rate with the moving object, and yet by a motion free from irregularity and tremor.

The value of a silver reflector turns, of course, entirely upon the perfection of the glass concave on which the metallic film is to be deposited. This must be of a parabolic figure, so that spherical aberration may be completely corrected. A person is, however, content to take the utmost pains to produce it, because, once attained, the figure cannot be lost except by fracture, and the value does not diminish with time as in the case of a speculum. It never requires re-polishing. The best method of grinding and polishing the glass is by means of an apparatus that I have called a "Local-correcting Machine," by which all the parts of the surface can be attacked in succession and reduced to the desired curvature, and yet at the same time a uniform curve and absence of local irregularities secured. I have spent five years in the investigation of this subject, and have polished more than 100 mirrors of from 19 inches to one-fourth of an inch in diameter, on seven different machines built at various times. The quality of those I have at present is indicated by the fact that they will show *Debillisima* to be quintuple, and will render the close companion of Sirius, discovered by Alvan Clark's magnificent 18½-inch refractor, visible.

The Observatory at Hastings-upon-Hudson, near New York, lat. 40° 59′ 25″ N., long. 73° 52′ 25″ W. of Greenwich, is upon the summit of a hill 225 feet above low-water mark. It is 20 feet square, with a wing 9 × 10 for a photographic laboratory. As the telescope is a Newtonian, with the mounting so contrived as to have the eyepiece stationary at all altitudes, a plan originally suggested by Miss Herschel, there are peculiar facilities offered for easy access to the eyepiece, or place of the sensitive plate. The interior height of the Observatory, 22 feet, is divided into two stories, around the upper of which an observer's chair runs to follow the telescope. The dome turns upon a pivot at its centre, instead of on rollers or cannon-balls around the edge, and is moved consequently with but slight exertion.



In the woodcut *a* is the telescope tube, *b* one of the trunnions on friction rollers perforated for the eye-piece, *c* one of the counterpoise levers, having a weight at the upper end and being attached to an axle *d* at the lower end; *e e′ e″* is a wire-rope going from the counterpoise to the lower end of the telescope; *f f* another wire-rope which passes round a small drum connected with the winch *g*, and gives the observer standing on the observer's platform *i* the power of moving the telescope in altitude; *k* the stairs going to the photographic room, *l l′* the gallery that divides the Observatory into two stories, *m* the azimuth axis resting on the solid rock, and sustained at its upper end by the three lateral beams, *n n′* (two only are shown). They also rest in cavities in the rock. The dome is seen in section at *o o′*, the dome-opening and shutter at *p*, the dome-arch at *q q′*. The dome-raising lever *r*, with the fulcrum at *s*, is shown as it appears when the dome is prepared for revolving, the axis *t* carrying the whole weight. The part of the lever below the detent *u* can be bent up out of the way, and held by a loop.

Since the telescope has been completed, and furnished with two parabolic mirrors of $15\frac{1}{2}$ inches aperture, and 150 inches focal length, and one Herschelian mirror (that is, a concave of such figure that it can only bring oblique pencils to a focus free from aberration), Celestial Photography has been continually prosecuted. About 1,500 lunar negatives have been taken. Old experience obtained from portrait and microscopic photography has proved to be of great service. At first the well-known processes were used, but it was soon found that something more refined was needed, where the pictures are to be submitted to magnifying powers of perhaps 25 times. Defects in collodion negatives that would, under ordinary circumstances, pass unnoticed, assume such prominence as greatly to diminish the beauty of the results. These defects, pin-holes, coarse granular appearance of the reduced silver, and other markings, were found to arise principally from the presence of nitrate of silver on the sensitive plate. It was ascertained that by washing the plate thoroughly before exposure they disappeared, or were very much ameliorated, and without any reduction in sensitiveness. But for this washing operation pure water is needed, and hence the roof of the buildings was painted with a ground mineral compound that hardens to a stony consistence, and the water falling upon it was preserved in a leaden tank, which from long use for other purposes had become thickly coated with insoluble salts of lead, sulphates, &c. Whenever an inch of rain falls, a ton of water is collected, and the tank may be filled about 32 times in a year.

The negatives produced at the focus of the reflector are on an average $1\frac{4}{10}$ inches in diameter. Many that have been made will bear to be enlarged to 2 feet, and one was taken September 3, 1863, at 4.30 A.M., which has been increased to 3 feet in diameter, the total magnifying power used being about 380. In this photograph the moon may be said to be shown on a scale of 60 miles to the inch.

In the process of enlarging I have introduced one very important novelty. Instead of employing an achromatic combination of lenses arranged as a solar camera, a *concave mirror* is used. It entirely gets rid of the difficulty of chromatic aberration, which is, as all photographers know, one of the most serious obstacles to success, and, in addition, the magnified image lies in one plane, or there is what is termed a *flat field*. Every little detail of the original negative is perfectly reproduced, and a 3-foot image is as sharp in one part as in another. The effect of portraits reproduced of life-size is very striking, and the resemblance to the individual singularly increased. In magnifying these lunar negatives, a mirror of 8 inches' aperture and 11½ inches' focal length is used. At first, when it was intended to employ diffused daylight and the whole aperture, the figure was made elliptical, with a distance of 8 feet between the conjugate foci; but subsequently, when the advantages of sunlight were understood, the surface was reduced by a diaphragm to 1½ inches in diameter, and a part of the mirror as nearly perfect as a mirror can be made at present was selected. Success in enlargement becomes with this contrivance a certainty.

The "enlarger" is also equally valuable in copying by contact. When a small negative is enlarged and photographed, what is termed a positive results. If such a positive is used to make prints on paper, the lights and shades are inverted, and that which is white is shown black. It is necessary then to turn the original negative into a positive, so that when magnified a negative may result suitable for printing positive proofs on paper. This is done usually by a process called reversing, in which a sensitive plate is placed behind the original negative, and the two exposed to the light. Wherever the negative is transparent the plate behind is stained by the light, and where opaque, it is protected. But unless the plate behind is so close as to make the chances of scratching the negative very great, the positive produced is much inferior in distinctness, because the diffused light of day finds its way through in many directions. If, however, the negative and sensitive plate are placed in the beam of sunlight coming from the enlarger, the rays pass through only in one direction, and the reverse or positive is as sharp as the original negative.

Celestial photography is as yet only in its infancy. The results to which it has given origin, although excellent in many respects, have imperfections. But it seems probable that these may be overcome in the future, partly by means now within reach, and partly by others which may be discovered at any moment. In looking at a 3-foot photograph from such a distance that the eye can embrace it all at one glance, the general effect is certainly very fine, and superior to observation through the telescope with a similar power. The moon appears as it would if viewed from a stand-point 600 miles from its surface. Ranges of mountains, as the *Apennines*, seem as if projected out from the general level, while the great craters, such as *Plato*, *Theophilus*, and *Clavius*, are deeply excavated below. Grooves of vast extent, like those diverging from *Tycho*, and faults such as that running past *Kant* and *Catharina* on the one side, and *Tacitus* on the other towards *Lindenau*, still further break up the surface. The well-known seas and bright portions, so distinct to the naked eye, are lost in the multiplicity of the details into which they are resolved.

But coming more closely to the picture, and examining with a critical eye, it is apparent that, although the general effect is the same as would be perceived by looking at the moon itself, yet some of the minute details seen in the telescope with a high power are absent.

The reasons which lie at the bottom of this difficulty are connected to a certain degree with the photographic processes employed, but also to not a little extent with the condition of the air. The quality of the instrumental means used is, of course, of primary importance. A good photograph cannot be taken with an inferior telescope and clock.

The obstacles arising from photography result from the fact that the dark parts of the picture are not formed by a continuous sheet of material, but by an aggregation of granules which, though invisible to the unassisted eye, are seen when a high-enough magnifying power is employed. Their degree of visibility turns on the system of development used for bringing out the latent image on the sensitive plate. A picture injudiciously forced with pyrogallic acid will hardly bear any enlargement, though one made with sulphate of iron and a well-regulated exposure may be increased in diameter twenty-five times, without showing the granulations offensively. The influence of the structure of the collodion-film itself, too, is noticeable in pictures taken by the wet process; in the first place, being somewhat transparent, it permits a certain amount of lateral diffusion in the film, and a tendency to soften down the more minute details; and, in the second place, while wet it has quite a perceptible thickness, which is much diminished in drying, and the relation of the silver particles to one another changed.

I have attempted to avoid the faults connected with structure of the film by substituting dry collodion, and more particularly tannin plates for the wet. But though during the exposure to the celestial object the sensitive plate presents a glassy surface of extreme thinness, yet an indispensable preliminary to evoking the latent image is to soak the plate in water, and this introduces the more injurious of the two objections above urged. It was while trying this process that I ascertained the advantages that arise from warming the film during development,—the "hot-water process," as it is called. The attempt was also made to daguerreotype the original pictures at the focus of the telescope on silver plating, and also on *silvered glass*. In this case all lateral diffusion is entirely prevented, the light acting on a mathematical surface, and the relations of the film of silver to the glass not being disturbed by the subsequent manœuvres. But practically no advantage has arisen from these trials, because, as in the former instance, the whites in the resulting picture are not formed by a continuous stratum of mercurial amalgam. That this is the case is proved by the fact that such daguerreotypes can be copied by the electrotype, or a coating of isinglass, as was shown by Dr. Draper ('Phil. Mag.,' May, 1843). This is the first occasion on which silvered glass has been used for photographic purposes, and it may be well to point out its advantages. Owing probably to the perfect purity of the silver, it takes the coatings of iodine and bromine with uniformity all over; in silver plated by fire on copper, there used to be a tendency to insensitive spots, from the copper alloy coming out on the face of the silver, and so great was the annoyance, that, when my father was engaged in the experiments that led him to take the first portrait ever obtained from life, he was compelled to use sheets of pure silver alone. The light also seems to be able to impress the iodo-bromide in less time, and pictures of a rosy warmth are generally obtained. The only precaution necessary in practising this method of daguerreotyping is to fix the plate—that is, dissolve off the excess of sensitive material—with an alcoholic solution of cyanide of potassium, instead of an aqueous solution of hyposulphite of soda. The latter tends to split up the film of silver from the glass here and there, while the former does not. The subsequent washing, too, is most safely conducted with diluted common alcohol. The time of exposure is not, however, as short as in the wet-collodion process, at least six times the exposure being demanded; while if less is given, and the development over mercurial vapour be urged beyond the usual point, minute globules of mercury stud the silver all over, and ruin the proof.

The faults arising from atmospheric disturbances are easily understood. If an image of the planet Jupiter produced by a large telescope be allowed to move across a sensitive plate, and the plate be then developed, a dark streak nearly of the width of the image will appear. If this streak is closely examined, it will be observed that the passage of the planet seems to have taken place in an irregular way—by fits and starts as it were, and that instead of the mark being continuous like that of a pencil, it rather resembles a string of beads. The cause of this lack of continuity is to be found in the movements of the Earth's atmosphere. Or, if the eye is placed at the eyepiece of the telescope, and the edge of a planet or the moon watched, it is found to present a wavy outline instead of a sharp disc-like appearance. Any point in the surface, too, is seen to have a rapid vibratory motion.

Although the eye can emancipate itself to a certain extent from these disturbances, a photographic plate cannot. Every point tends then to assume a greater size and less distinctness than it should have, and if the night on which the trials are being made is very unsteady, the smaller details are so confused together that the picture is worthless. Occasionally, however, very still nights occur, when photographs of great beauty may be taken. In the interval between March and December, 1863, three such nights occurred, and on one of them the negative for the 3-foot was obtained.

It has been stated that there are no insuperable obstacles to the production of perfect celestial photographs,—that is, such as realize the full optical power of the telescope used. The atmospheric difficulty may be successfully combated by removing a large reflector from near the level of the sea to a considerable altitude, where a great part of the atmosphere is left behind. It seems to me that a suitable place for such a purpose would be the rainless west coast of South America, somewhere near the equator. Improvements, too, are continually being invented in photographic processes, and a considerable step is made when we find out what it is that we need. Quick methods are not so much required as those which will yield grainless pictures on structureless films, and unless the time of exposure could be so much shortened as to be but a small fraction of a single atmospheric pulsation, no particular advantage would be gained by their use.

The inducements to amateurs to prosecute the study of celestial photography are very great, and the apparatus required is such as any one of a mechanical turn may make. A great deal can and will be done in this branch of astronomy; and animated by the hope that many others may be induced to cultivate it, I have written the detailed account in the Smithsonian Contributions.

HENRY DRAPER, M.D.,
Professor of Natural Science in the University of New York.

The Brazilian Coal-fields. By Edward Hull, B.A., F.G.S.

THE immense empire of Brazil, occupying one-third of the continent of South America, with an area of upwards of 3,000,000 of square miles; considerably larger than Russia in Europe; watered by the largest river in the world, which with its tributaries is navigable for many hundred miles from its mouth; its western bounds stretching to the spurs of the Andes, and its eastern washed by the waves of two oceans—such a country as this would appear fitted to occupy the foremost rank amongst the nations of the Western hemisphere, provided its boundless resources were turned to account by an intelligent people, and civilization were advanced by wise laws. It is satisfactory to reflect, that while most of the surrounding republics—the shattered limbs of Spanish America—are tossed on the waves of anarchy, Brazil enjoys a peaceful government under a constitutional monarchy; personal freedom with political security; monarchical principles combined with popular rights. We notice these points in the government of Brazil, because they afford the highest guarantee of national progress, and the development of industrial pursuits. Nor are the raw materials necessary for the attainment of a high position amongst the manufacturing communities of the world absent from the soil of Brazil.

The northern half of the empire is physically not unlike the plain of Northern Italy on a large scale. Covered with forests springing from a rich alluvial soil, and watered by the Amazon and its giant branches, it is prodigiously fertile. The southern half is hilly, and sometimes mountainous, and gives birth to the Rio de la Plata. One of the peaks of the Organ Range rises behind the harbour of Rio de Janeiro, to an altitude of 7,500 feet. These and the neighbouring hills contain minerals and gems in abundance, and the Government has, with great spirit, undertaken a mineral survey of these southern provinces.

It was once supposed that this great empire — rich in precious stones, and nearly all the metals, from gold to iron inclusive—was devoid of one natural product, useful, if not absolutely essential, to the full utilization of the other mineral treasures — namely, coal; but such a supposition was altogether erroneous, as recent investigations have fully shown. A writer in a recent number of the 'Quarterly Review'* for 1860, mentions (on what authority is not stated) the existence of a coal-field upwards of 60 leagues in extent, and 40 miles from the sea. Considering that Brazil has a seaboard of more than 2,000 miles, the description of the locality is sufficiently vague; but, as far as it goes, the information is strictly correct; this, however, is all that was known on the subject on this side of the Atlantic till very recently.†

To a countryman of our own, Mr. Nathaniel Plant, we are indebted for a full account, through his brother, Mr. J. Plant, Curator of the Salford Museum, of the position and resources of three distinct coal-fields which he has recently explored in the southern part of the empire; the largest presents some features of peculiar interest, which we proceed briefly to lay before our readers.

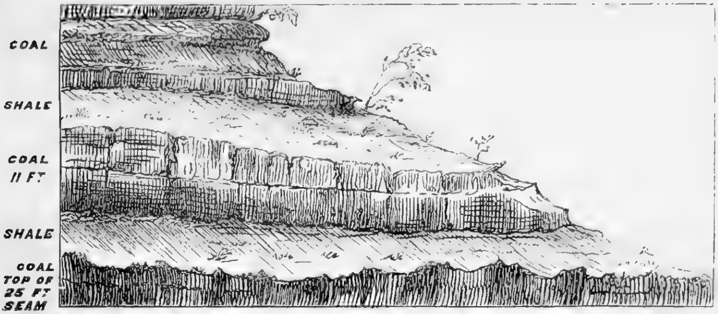
The first notice of these minerals seems to have been taken by Mr. Bonliech, son of the Governor of the province of Rio Grande do Sul, in which the largest of the three coal-fields is situated. This was in the year 1859, and it was probably through the report of this gentleman that the writer in the 'Quarterly Review' obtained his information. The matter, however, seems to have been lost sight of until the end of 1861. When Mr. Plant, who for several years had been examining the mineral districts of Rio Grande, in the service of the Imperial Government, determined to make a fuller exploration of the coal-district, and he has now sent to this country an account of the very remarkable deposits of mineral fuel he met with, together with those unbiassed witnesses—photographic views, and rock specimens.*

The Candiota field is the largest of three which have as yet been discovered. It extends from lat. 32° S. to 28° S., and is thus at the southern extremity of the province of Rio Grande do Sul. It is traversed by the river Jaguarao and several of its tributaries, along whose banks the seams of coal crop out. There are two great seams of bituminous coal, the lower being 25 feet in thickness, the upper part of which is shown in the sketch, and is separated by only a very few feet of shale from the upper bed (or series of beds), which is 40 feet in thickness.

* No. 216, page 338 in foot note.

† A correspondent of the 'Mining Journal,' No. 1484, states that "years since samples of the coals were sent to this country, and analysed by Dr. Percy." It may also be stated that specimens of coal from Brazil were shown in the Exhibition of 1862, and were reported on by Mr. W. W. Smyth, in Jury Reports.

* These have been laid before the Geological Society of Manchester by his brother, 1864.



Portion of Escarpment, showing the outcrop of the Coal-seams along the border of the Candiota Coal-field. Taken from a Photograph.

In some places, the intermediate bands of shale which separate the mineral into distinct layers thin away, in which case a solid seam of no less than 65 feet is formed, unsurpassed, we believe, in vertical dimensions by any similar formation yet discovered. We have handled specimens of the coal; and though taken from the outcrop, it is scarcely distinguishable, except by a slight brownish hue, from the ordinary coal of our own country.

The coal-strata repose on a series of shales, sandstones, and crystalline limestone, the whole of which are supported by mica-schist, and finally by syenite.

Iron is also present, as in the coal-formation of Britain, both in the form of bands of clay-ironstone, and as a roof for the seams of coal. At the top of the cliffs formed by the outcrop of the coal-seam there occurs a mass of silicious iron-ore, several yards in thickness, a sheet-casting from which was sent to the late Industrial Exhibition amongst the other Brazilian products. Thus there occurs in close proximity to each other, the ore, the fuel, the flux, and the clay, necessary for the establishment of iron-furnaces.

The several minerals thus united rise in the form of an elevated escarpment (a portion of which is represented in the engraving), which may be traced for several leagues, affording the utmost facility for working by open-work, or tunnels driven into the sides of the hill. From its base stretches a gently sloping plain of basalt, over which a railway to a port in the Rio Gonzalo might be laid down at a very moderate cost. Sailing-vessels of 100 tons burden can navigate this river to the town of Jaguarao, 20 miles from the borders of the coal-field, between which and the important port of Rio Grande de San Pedro, on the Atlantic, there is at present a flourishing trade.

The second coal-field which has been observed, lies about 100 leagues to the north of the Candiota field, in the valley of the Rio dos Ratos, near Porto Alegre, the capital of the province. It is not of large extent, but well situated for carriage by river and lake; nothing has, however, yet been done to develope its resources.

The third coal-field is in the small province of San Catharina, lying north-east of the Rio Grande do Sul. It is reported to occupy an area of about 80 square miles, in the midst of a range of hills, and is not so accessible to commerce as the other two tracts.

It is not improbable that each of these coal-fields, lying as they do in a direct line parallel with the coast, is of the same geological age; and after an inspection of the fossil plants which have been sent over to this country, there cannot be a doubt, we think, that this age is the Carboniferous. Mr. Plant has sent over several pieces of ironstone, on which are imprinted very distinct specimens of *Lepidodendron*, and several ferns not unlike those of the coal-measures of Britain. A gentleman, also, who has studied the coal-measures of Nova Scotia, which are of the same age as those of Britain, refers, in a letter which we have seen, to fine specimens of *Sigillaria* and *Stigmaria*, both of which are characteristic of this period. Specimens of these, however, are not in the collection we have examined, but nothing can be more distinct than the fronds of Lepidodendron already referred to. While on this subject we may be allowed to remark, that although, on the authority of Professor M'Coy, the age of the Australian coal-fields was for some time considered to be Jurassic, the recent investigations of the Rev. W. B. Clarke go to establish the Carboniferous age of these beds. Mr. Clarke has sent to England a collection of fossils from the New South Wales coal-field,* containing specimens of *Lepidendron* and *Spirifer;* and thus it would appear that, during the same great epoch, so pre-eminently carboniferous, deposits of coal were being elaborated over both hemispheres and on both sides of the equator; a marvellous instance of the uniformity of nature's operations in early geologic times.

The importance of these great deposits to the commerce of the eastern seaboard of South America need not be dwelt upon. At the present time, 250,000 tons of coal are annually imported into Rio Janeiro, at a cost of 49*s.* per ton, and from this depôt other coast-towns are supplied. When once the coal-field of Candiota is opened up, the Brazilian Government may be supplied at less than half the price, and our own little Island be spared the doubtful honour of providing fuel for a continent on the other side of the globe.

EDWARD HULL.

* In the Museum of the Geological Society of London, Somerset House.

Malt as Cattle Food. By J. Chalmers Morton.

STREATLEY, *near Reading.*

YOUR agricultural chronicle will doubtless place before your readers the fact that a bill has been introduced into Parliament, which will probably pass into law, for permitting the use of malt duty free in feeding sheep and cattle. They may, however, wish to know the probabilities of this measure proving agriculturally serviceable, more in detail than the limits of the chronicle will enable you there to discuss them.

The measure has probably originated in the interview with which the Chancellor of the Exchequer honoured a deputation of the Central Farmers' Club early last year, when Mr. Booth of Warlaby, Mr. Arkell of Swindon, and Mr. Williams of Baydon, all well-known agriculturists, declared to him that malt is greatly superior to barley as food for cattle and for sheep; and when Mr. Williams in particular put the case of an English farmer who had fed 300 sheep on a lot of spoiled malt, and was refused a drawback of the duty, though this would have been allowed to him had he exported the malt to a French farmer, who might thereafter have sent his sheep, fattened on this very malt, for sale at Smithfield. "Thus, while the foreigner might have the advantage of feeding his sheep on malt without paying any duty, the British farmer, if he wished to feed his sheep on malt, was subject to a tax of 21*s.* 8*d.* per quarter." The inconsistency of this was obvious enough to the logical mind to whom it was thus presented, and accordingly we have now a Bill which will for the future put an end to so great an anomaly! Barley may, for the future, in houses set apart for the purpose, be malted; and the malt may be dried and ground, with 10 per cent. of linseed, to a certain degree of fineness, and it may be thereafter sold under certain conditions, duty free, for feeding purposes. And no English farmer will hereafter be able to complain that he is being undersold in the meat market by foreign mutton more cheaply fed than his own. Will this lead to any cheapening of the meat manufacture here? I think not.

What are the circumstances? On the one hand, we have the practical experience only of the few men who, in spite of the duty hitherto, have used it for the purpose of putting the last finish to the fattening process, when the pampered appetite of the animal intended for exhibition refuses everything but an unusual dainty. Liebig also writes to Mr. Bass, M.P., a letter, which may, however, be quoted by either party to the discussion, but referring especially to the greater digestibility of the malted barley. The letter is as follows:—

"In forming a judgment on the feeding properties of malt, when given to horses, cattle, and sheep, it is obvious that in comparing it with barley we must not lose sight of the fact that there is a larger amount of nourishment in barley than in the malt manufactured from it; for in the process of malting barley suffers a loss in weight amounting to from 7 to 11 per cent. of dry substance. The 'rootlets' constitute 3 to $3\frac{1}{2}$ per cent. of this loss, and as they contain a pretty large quantity of blood-forming (nitrogenous) matter (25 to 30 per cent.), the grain, by their separation from it, undergoes a loss of one of its nutritive elements. Hence it is clear that if in practice the feeding qualities of malt are found to be greater than those of barley, this can only arise from the circumstance that the nutritive matter contained in malt is present there in a more soluble, more digestible state than in barley; and that therefore in feeding with barley more nutritive matter leaves the body in an undigested state than is the case when an equal weight of malt is used as food. There can be no doubt whatever that in malt blood-forming matter is contained in a more soluble form than in barley; for the process of malting occasions a loosening of the component parts of the grain in so great a degree that 100 volumes of dry barley yield (notwithstanding the loss of weight) 112 to 114 volumes of dry malt. Such a loosening of the inner parts of the grain, thus enabling the gastric juice in the animal body to penetrate it more easily and thoroughly, is not to be attained in like degree by a mechanical process. The comparative analysis shows finally that the amount of readily soluble blood-forming elements in barley is $1\frac{1}{4}$ per cent., and in malt $2 \cdot 2\frac{1}{8}$ per cent. By the process of drying in the kiln, a part of the soluble blood-forming elements is rendered insoluble, and from this it cannot add to the feeding capabilities."

On the other hand, there is, in addition to the considerations against the economy of malt which this letter urges, the fact that in the case of ruminating animals, for which the farmer will principally use it, there can hardly be any room for the idea that increased digestibility will prove advantageous. Indeed, the increased solubility of the food, especially, mixed, as it will be, with linseed meal, will tend to its passage with wasteful rapidity through the digestive organs. And there is also the fact that a very great waste of substance takes place in malting. If barley after being malted will occupy a rather larger space than it did, the loss of weight per bushel is in great excess of any advantage there. The loss of weight on the whole does indeed generally exceed 20 per cent., and this is too large to be counterbalanced by any improvement the substance may have acquired, whether in digestibility or otherwise, during the process.

Apart, however, altogether from the relative merits of barley and malt as food for cattle and sheep, there are cheaper and better foods now in use than either of them will ever be. Except in pig-feeding, where barley is the chief food used, it is of but little service in our meat manufacture. Oilcakes of various kinds, peas, beans, linseed, carob pods, oats, and even wheat, must be named before it on the list of foods for the stable, feeding stall, or sheep-fold. And, if the mixed malt and linseed, both of them relaxing substances, which are offered to him duty free, be experimented on by the cattle-feeder, he must add a large proportion of bean meal, or some other astringent substance, to correct a tendency which will rather check than help the fattening process; while if used merely to induce the saccharine fermentation in other meals, which would form the bulk of the food administered, the small quantity wanted for that purpose is not worth the legislation which has been demanded for it. The real object of the existing agitation on this subject no doubt is, that we may have malt free for man. And the point, practically worthless and unimportant, but theoretically indefensible, which was pointed out by Mr. Williams to Mr. Gladstone, and on which the present Bill is founded, will have served a useful purpose if it shall in any degree have helped to remove what is undoubtedly a demoralizing, and, excepting to the tenants of good barley-growing districts, a generally mischievous impost.

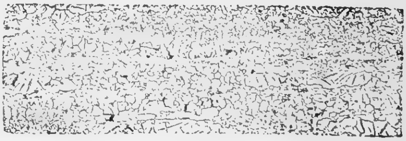
J. C. Morton,
Ed. 'Agricultural Cyclopedia.'

March, 1864.

A New Method of Illustrating the Structure of Blister Steel, by Nature Printing. By H. C. Sorby, F.R.S.

Broomfield, *near Sheffield, March*, 1864.

When iron is converted into steel by cementation, three distinct crystalline compounds are formed, two of which are readily dissolved by diluted nitric acid, whereas one is scarcely at all affected by it. If, therefore, a piece of such steel be ground flat and polished, and then placed in the acid, after a suitable amount of action, this constituent retains its original surface and polish, whereas the other two are so much dissolved that it stands up in sufficient relief to allow of the blocks being used for surface printing instead of a woodcut, to exhibit the structure of different varieties of steel. At the late conversazione of the Sheffield Literary and Philosophical Society, specimens were printed showing the appearance of a square bar of iron once converted (transverse section), iron remaining in the centre; a flat bar of iron, slightly converted, the crystals being small; a square bar of iron twice converted (transverse section), showing the centre incompletely converted; a flat bar of iron, highly converted, the crystals being rather large; a round bar of "homogeneous metal," converted (transverse section); and a flat bar of hammered cast steel, reconverted, the crystals being very large. In order that you may convey to your readers some idea of the appearances thus presented, I send you herewith a small block of prepared metal, capable of being employed as a woodcut.



It is a transverse section of "blister steel," from a flat bar of iron highly converted. The best method of viewing the prints is by mounting them as stereoscopic objects, for they appear to great advantage under such a magnifying power. Though far more suitable for blister steel than for any other metal, yet still prints may be obtained from sections of armour-plates and other varieties of iron, which show certain peculiarities in their structure in a very satisfactory manner.

H. C. Sorby, F.R.S., &c.

Books received for Review.

From *Messrs. Longman & Co.*:—

The Story of the Guns. By Sir J. Emerson Tennent, K.C.S., F.R.S. Illustrated. 400 pp. 8vo.

Elements of Physics, or Natural Philosophy. Written for general use in plain or non-technical language, by Neil Arnott, M.D., F.R.S., &c. 6th and completed Edition. Part I. 430 pp. 8vo.

A Guide to Geology. By John Phillips, M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford. 5th Edition. Illustrated. 320 pp.

The Battle of the Standards; the Ancient of Four Thousand Years against the Modern of the last Fifty Years, the less perfect of the two. By John Taylor, author of 'The Great Pyramid, why was it built?' 100 pp. 8vo.

Biographical Sketch of Sir Benjamin Brodie, late Sergeant-Surgeon to the Queen and President of the Royal Society. By Henry W. Acland, Regius Professor of Medicine in the University of Oxford. 30 pp. 8vo.

The Principles of Agriculture. By Wm. Bland, M.R.A.S., author of 'The Principles of Construction in Arches, Piers, Buttresses, &c.' 2nd Edition. 140 pp.

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British Conchology, or an Account of the Mollusca which inhabit the British Isles and the surrounding Seas. Vol. II. Marine Shells, comprising the Brachiopoda and Conchifera from the Family Anomiidæ to that of Mactridæ. By John Gwyn Jeffreys, F.R.S., F.G.S., &c. 8 plates. 480 pp.

From *Messrs. John Churchill & Sons*:—

Hardwich's Photographic Chemistry. 7th Edition. Revised by G. Dawson, M.A., Lecturer on Photography, King's College, London; and E. A. Hadow, Demonstrator of Chemistry, King's College, London. Illustrated. 608 pp.

The Second Step in Chemistry, or the Student's Guide to the Higher Branches of the Science. By Robert Galloway, F.C.S., Professor of Practical Chemistry in the Museum of Irish Industry. Dublin. Illustrated. 792 pp.

From *Mr. Stanford*:—

Pure Logic, or the Logic of Quality apart from Quantity; with remark's on Booles System and on the relation of Logic and Mathematics. By W. Stanley Jevons, M.A. 85 pp.

From *Messrs. A. Brown & Co., Aberdeen*:—

The Botanist's Guide to the Counties of Aberdeen, Banff, and Kincardine. By G. Dickie, A.M., M.D., Professor of Botany in the University of Aberdeen. Map. 350 pp. 8vo.

From *the Author*:—

A Handbook of Descriptive and Practical Astronomy. By George F. Chambers, F.R.G.S. Illustrated. 560 pp. (J. Murray, 1861.)

PAMPHLETS.

LECTURES AND ADDRESSES.

The Power of God in His Animal Creation. By Professor R. Owen, D.C.L. Exeter Hall Lecture.

Anniversary Address, Geological Society of London. By Professor A. C. Ramsay, F.R.S., President. (Taylor & Francis.)

Address of the President of the Institution of Civil Engineers, J. R. M'Lean, Esq., F.R.A.S. 1863-4. (Clowes & Sons.)

Address of the President of the West Kent Natural History, Microscopical and Photographic Society. Fredk. Currey, Esq., M.A., F.R.S., &c., with Report, &c. (Crockford, Greenwich).

Address of the President of the Bath Natural History and Antiquarian Field Club. Revd. Leonard Jenyns, M.A., F.L.S., &c. (Hayward, *Express* Office, Bath).

Rules for Zoological Nomenclature. By the late Hugh E. Strickland. Reprinted by Sect. D. British Association. (Neill, Edinburgh.)

On Deficiency of Vital Power in Disease, and on Support. By Lionel S. Beale, M.B., F.R.S., F.R.C.P., &c. (T. Richards.)

Observations upon the Essential Changes occurring in Inflammation. A Lecture. Same Author. (Deey, Dublin.)

The Patent Question. A Paper read at the Association for the Promotion of Social Science, Edinburgh, by R. A. Macfie, President, Liverpool Chamber of Commerce. (W. J. Johnson, London.)

PERIODICALS.

The Chemical News.—Revue Universelle des Mines, &c., sous la direction de M. Ch. de Cuyper. Noblet & Baudry, Paris and Liège.—The Dublin Quarterly Journal of Science.—Artizan.

REPRINTS.

Vegetable Morphology. By M. T. Masters, F.L.S.—Goethe's Essay on the Metamorphosis of Plants. Translated by Emily M. Cox, notes by M. T. Masters, M.D.—Properties of Electro-deposited Antimony. George Gore.—Observations on the Planet Mars. By J. Norman Lockyer, F.R.A.S.—Notes sur la Fabrication de l'Acier en Angleterre. Par E. Grateau, Ing. civil des Mines. Paris.—Les Polynesiens et Leurs Migrations. A. de Quatrefages, Membre de l'Institut de France.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

The Royal—Royal Geographical—Ethnological—Geological—Royal Astronomical—Microscopical—Zoological: all of London.

Liverpool Literary and Philosophical Society.

Transactions of the North of England Institute of Mining Engineers. October and November, 1863. On the Discovery of Rock Salt at Middlesbro.' By John Marley.

La Societe Batave de Philosophie Experimentale de Rotterdam.

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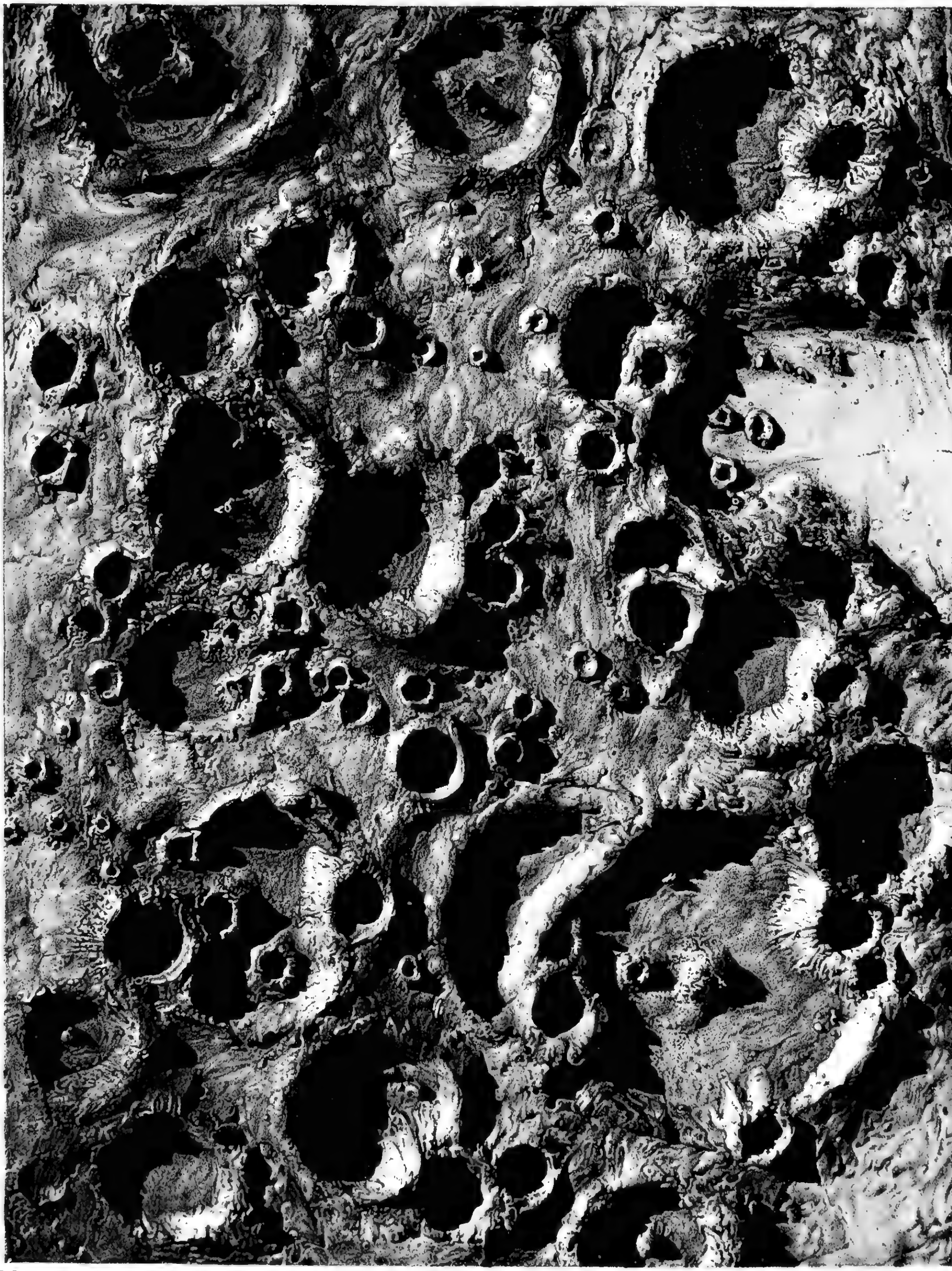


M & N Hanhart imp.

James Nasmyth

THE QUARTERLY

JOURNAL OF SCIENCE.

JULY, 1864.

ORIGINAL ARTICLES.

ON THE PHYSICAL ASPECTS OF THE MOON'S SURFACE.

By James Nasmyth.

The desire to know something of other worlds besides our own has ever been a prominent one with intelligent minds, and as the telescope has enabled us virtually to reduce the distance between ourselves and those remote orbs that revolve around the sun, many facts have thus been elicited concerning their physical constitution.

Interesting as such facts may be, they are vague and insufficient as compared with those which the telescope has revealed to us, in regard to our nearest celestial neighbour, the Moon, whose comparative proximity enables us, even by the aid of a moderate magnifying power, to gain a very exact knowledge of the physical structure of her surface.

As the Moon's hemisphere, which is ever turned towards us, has its features illuminated in opposite directions during her monthly passage in her orbit around the earth, every part of it is exposed in turn to the rays of the sun, which fall on the details of its features in constantly varying inclinations; and it is from this circumstance that we have such favourable opportunities afforded to us of obtaining a very correct knowledge of the configuration of the details in question, as well as of their height or depression above or below the mean level of the Moon's general surface. Thus it is that we are enabled most carefully to scrutinize her remarkable surface; and should we have drawn any hasty inferences from one set of observations, the opportunity is usually presented to us in the course of a fortnight, or at farthest a month, to correct them if erroneous, or to verify them if accurate, and to pursue further investigations that may be suggested by reflection on what we had last observed.

In these respects telescopic visits to the surface of the moon yield more correct and reliable results than would many a visit to portions of our world where the scenery to be surveyed is not, perhaps, conveniently accessible; and even when it is reached, the traveller may be surrounded by circumstances which very seriously interfere with his personal comfort, or disturb that tranquillity which is so requisite a condition for close and accurate observation, and thus lead him to hasty conclusions, which he has no future opportunity to rectify. In strong contrast with such circumstances is the position of the astronomer, comfortably placed beside his telescope, in the silence and tranquillity of a fine clear night, with all distracting objects excluded from his view. The whole of his attention is thus brought to focus, as it were, on the point under investigation there and then presented to his scrutiny, and ready to yield perfectly truthful replies to his questions; nothing being requisite for a correct interpretation of facts, other than a quick eye backed by a sound and unbiassed judgment.

It is from circumstances such as these that we have acquired, by a long course of assiduous observation and reflection, an amount of intimate acquaintance with the physical structure of the Moon's exterior, in many important respects far more accurate than is our knowledge of that portion of the earth.

In order rightly to interpret the details of the Moon's surface, as revealed to us by the aid of the telescope, we ought, in the first place, to bear in mind the true nature of volcanic action, namely, that while it has reference to the existence of intense temperature and molten matter, it does not derive its origin from *combustion*, considered as such in a strictly chemical sense, but proceeds from an incandescent condition, induced in matter by the action of that great cosmical law which caused an intense heat to result from the gravitation of particles of matter towards a common centre. These particles, originally existing in a diffused condition, were, by the action of gravitation, made to coalesce, and so to form a planet. Volcanic action, then, has in all probability for its source the heat consequent upon the collapse of such diffused matter, resulting in that molten condition through which there is strong reason to believe all planetary bodies to have passed in their primitive state, and of which condition the geological history of our earth furnishes abundant evidence. Thus the molten lava which we see issuing from an active volcano on the earth, is really and truly a residual portion of that molten matter of which the entire globe once consisted.

In reference to the nature and origin of that eruptive force which had, again and again in the early periods of the Moon's history, caused the remaining molten matter of her interior to be ejected from beneath her solidified crust, and so to assume nearly every variety of volcanic formation in its most characteristic aspect, the key to these may be found in the action of that law which pervades almost all matter in a molten condition, namely, that "molten matter occupies less bulk, weight for weight, than the same material when it has ceased from the molten state;" or, in other words, that "matter in a molten state is specifically more dense than the same material in a solidified condition." Thus it is that in passing from the molten to the solid state the normal law is resumed, and expansion of bulk either just immediately precedes or accompanies solidification. It is, therefore, in this expansion in the bulk of the solidifying matter, beneath the Moon's crust, that we are to look for the true cause of that eruptive or ejective action which has resulted in the displacement, *surface-ward*, of the fluid portion of the Moon's internal substance; a displacement which has manifested itself in nearly every variety of volcanic formation, such as circular craters with their central cones or mountains of exudation, cracked districts, &c.; all these variations of well-recognized volcanic phenomena being intermingled and overlaid one upon the other in the most striking and wonderful manner. In illustration of this, I would here refer the reader to the lithograph which accompanies this paper, and which has been selected as a fair type of the greater part of the lunar surface where such volcanic features are characteristically displayed.

It may, however, be very reasonably and naturally asked, "What evidence have I that the features I refer to have any relation to volcanic action at all?" In reply to such a question I would direct the inquirer's attention to one single feature which, I conceive, demonstrates more completely than any other the fact of volcanic action having (at however remote a period) existed in full activity in the Moon. The special feature to which I would refer is the central cone that may be observed within those "Ring-formed mountains," as they have been termed. "The central cone" is a well-known and distinctive feature in terrestrial volcanoes. It is the residue of the last expiring efforts of a once energetic eruptive volcanic action, which had thrown the ejected matter to such a considerable distance round about the volcanic vent, that in its descent it had accumulated around in the form of a ring-shaped mountain or crater, whilst on the subsidence of this volcanic energy, the ejected matter was deposited in the immediate vicinity of the vent or volcanic orifice, and thus arose the "central cone."

Anyone who is familiar with terrestrial volcanic craters must, at the first glance at those which are scattered in such infinite numbers over the Moon's surface, detect this well-known analogous feature, the central cone, and at once reasonably infer that these similar forms arose from a common cause, that cause being no other than volcanic action, accompanied by all its most marked characteristics.

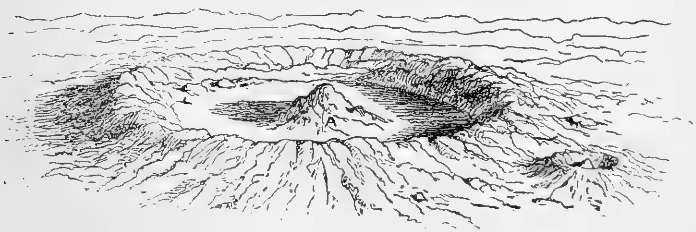


FIG. 1.

Fig. 1. Represents a fair average type of the structure of a Lunar Volcanic Crater with its central cone A.

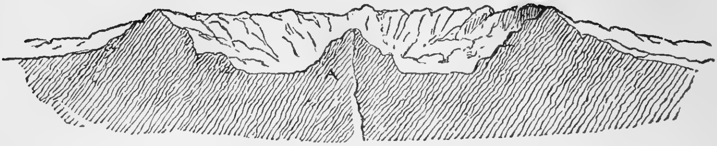


FIG. 2.

Fig. 2. The same in section.

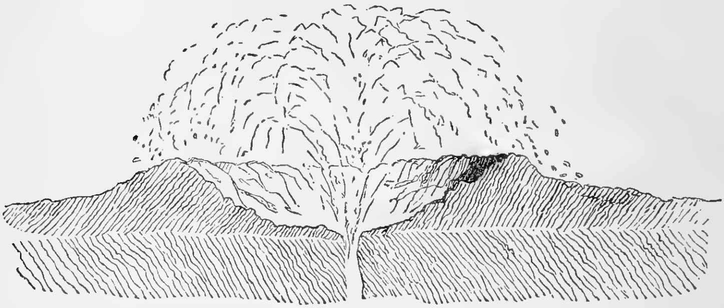


FIG. 3.

Fig. 3. Is the section of a Lunar Crater, showing how by the eruption, and subsequent deposition of the ejected matter, the circular outer wall or crater had been formed.

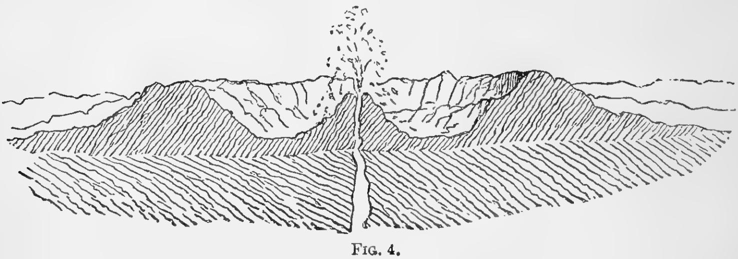


FIG. 4.

Fig. 4. The section of the same, exhibiting the manner in which the central cone had resulted from the expiring efforts of the eruptive action.

In examining the Moon's surface, we cannot but be impressed with the vast dimensions of many of the volcanic craters with which her surface is studded. Craters of thirty miles and upwards in diameter are by no means uncommon, and the first impression on the mind in reference to such magnitudes is one of astonishment, that so small a planet as the Moon (whose magnitude is only about $\frac{1}{49}$th that of the earth) should exhibit evidence of volcanic violence so far greater than any that we have on the earth. This apparent paradox will, however, disappear when we come to consider that in consequence of the Moon being so much less than the earth, the force of gravity on its exterior is not above $\frac{1}{6}$th of that on the earth, and that the weight of the lunar materials on its surface is reduced in the latter proportion, while, on the other hand, by reason of the small magnitude of the Moon and its proportionately much larger surface in ratio to its magnitude, the rate at which it parted with its original cosmical heat must have been vastly more rapid than in the case of the earth. Now, as the disruptive and eruptive action and energy are in proportion to the greater rate of cooling, those forces must have been much greater in the first instance; and, operating as they did on matter so much reduced in weight as it must be on the surface of the Moon, we thus find in combination two conditions most favourable to the display of volcanic force in the highest degree of violence. Moreover, as the ejected material in its passage from the centre of discharge had not to encounter any atmospheric resistance, it was left to continue the primary impulse of the ejection in the most free and uninterrupted manner, and thus to deposit itself at distances from the volcanic vent so much greater than those of which we have any example in the earth, as to result in the formation of the craters of vast magnitude so frequently encountered in a survey of the Moon's surface. In like manner we find the ejected matter piled up to heights such as create the utmost astonishment; Lunar Mountains of 10,000 feet high are of frequent occurrence, while there are several of much greater altitude, some reaching the vast height of 28,000 feet, and that almost at one bound, as they start up directly from the plane over which they are seen to cast their long black, steeple-like shadows for many a mile; whilst at other times they intercept the rays of the sun upon their highest peaks many hours before their bases emerge from the profound darkness of the long lunar night.

Among the many terribly sublime scenes with which the Moon's surface must abound, none can be grander than that which would present itself to the spectator, were he placed inside of one of these vast volcanic craters (Tycho, for instance), surrounded on every side by the most terrific evidences of volcanic force in its wildest features.

In such a position he would have before him, starting up from the vast plane below, a mighty obelisk-shaped mountain of some 9,000 feet in height, casting its intense black shadow over the plateau; and partly up its slope he would see an amphitheatrical range of mountains beyond, which, in spite of their being about forty miles distant, would appear almost in his immediate proximity (owing to the absence of that "aerial perspective," which in terrestrial scenery imparts a softened aspect to the distant object), so near, indeed, as to reveal every cleft and chasm to the naked eye! This strange commingling of near and distant objects, the inevitable visual consequence of the absence of atmosphere or water, must impart to lunar scenery a terrible aspect; a stern wildness, which may aptly be termed unearthly. And when we seek to picture to ourselves, in addition to the lineaments and conditions of the lunar landscape, the awful effect of an absolutely black firmament, in which every star, visible above the horizon, would shine with a steady brilliancy (all causes of scintillation or twinkling being absent, as these effects are due to the presence of variously heated strata, or currents in our atmosphere), or of the vivid and glaring sunlight, with which we have nothing to compare in our subdued solar illumination, made more striking by the contrast of an intensely black sky; if, we say, we would picture to ourselves the wild and unearthly scene that would thus be presented to our gaze, we must search for it in the recollection of some fearful dream.

That such a state of things does exist in the Moon we have no reason whatever to doubt, if we may be permitted to judge from inferences reasonably and legitimately deduced from the phenomena on its surface revealed by the telescope; neither can there be a question as to the presence there of the same brilliant tints and hues which accompany volcanic phenomena in terrestrial craters, and which must lend additional effect to the aspect of lunar scenery. Nor must we omit, whilst touching upon the scene that would meet the eye of one placed on the Moon's surface, the wonderful appearance that would be presented by our globe, viewed from the side of the Moon which faces earthward. Possessing sixteen times the superficial area, or four times the diameter, which the Moon exhibits to us, situated high up in the lunar heavens, passing through all the phases of a mighty moon, its external aspect ever changing rapidly as it revolves upon its axis in the brief space of four-and-twenty hours, what a glorious orb it would appear! Whilst its atmospheric phenomena, due to its alternating seasons, and the varying states of weather, would afford a constant source of interest. But, alas! there can be none to witness all these glories, for if ever man was justified in forming a conclusion which possesses the elements of certainty, it is that there can be no organized form of life, animal or vegetable, of which we have any cognizance, that would be able to exist upon the Moon.

Every condition essential to vitality, with which we are conversant, appears to be wanting. No air, no water, but a glaring sun, which pours its fierce burning rays without any modifying influence for fourteen days unceasingly upon the surface, until the resulting temperature may be estimated to have reached fully 212°; and no sooner has that set on any portion of the lunar periphery than a withering cold supervenes; the "cold of space" itself, which must cause the temperature to sink, in all probability, to 250° below zero. What plant, what animal could possibly survive such alternations of heat and cold recurring every fourteen days, or the accompanying climatic conditions?

But let us not suppose, because the Moon is thus unfitted for animal or vegetable existence as known to us, that it is necessarily a useless waste of extinct volcanoes. Apart from its value as "a lamp to the earth," it has a noble task to perform in preventing the stagnation that would otherwise take place in our ocean, which would, without its influence, be one vast stagnant pool, but is now maintained in constant, healthy activity, through the agency of the tides that sweep our shores every four-and-twenty hours, bearing away with them to sea, all that decaying refuse which would otherwise accumulate at the mouths of rivers, there to corrupt, and spread death and pestilence around. This evil, then, the Moon arrests effectively, and with the tides for a mighty broom, it daily sweeps and purifies our coasts of all that might be dangerous or offensive.

But there is still another duty that she fulfils—namely, in performing the work of a "tug" in bringing vessels up our tidal rivers. Dwellers in seaports, or those who reside in towns situated up our tidal streams, have excellent opportunities of observing and appreciating her value in her towing capacity; and, indeed, it may with truth be said that no small portion of the corn with which we are nourished, and of the coal that glows in our firesides, is brought almost up to our very doors by the direct agency of the Moon.

GUN-COTTON.

By John Scott Russell, C.E., F.R.S.

The elements are proverbially good servants, but bad masters—Fire, water, wind, and steam are fierce demons when they get the upper hand; yet what would civilization be, wanting the fire of the kitchen, the smith's hearth, and the foundry; how should we be, without seas to carry our boats or rivers to turn our mills? Commerce and merchandise are mainly conducted by the wind and the sails of our merchantmen; and steam clothes us, and carries us from city to farm, and from island to continent; yet the earthquake, the volcano, the conflagration, the torrent, the storm, the hurricane, and the explosion —what are they but servants become masters?

It is peculiarly true of steam and gunpowder that they are among the most useful, and most dangerous of human inventions; but danger in both is generally admitted to be a matter merely of skill and care. No one proposes to put down railways because a locomotive explodes, or to give up shooting because a gun has burst, or a gunpowder manufactory blown up.

Gun-cotton is a new power coming under the same category as steam and gunpowder. It is highly dangerous to those who don't possess the necessary knowledge and skill; but, like them, it enormously extends human power, and, like them, the skill to use it can be rightly and certainly acquired.

The object of this paper is to extend the knowledge and skill of my countrymen in the use of this new power. It is, I believe, of far more value to England than to any other nation in the world. It is, in my opinion, a power capable of being extensively used for a multitude of purposes yet unheard of; and I believe it will play an important part in the destinies of England.

The first question we naturally ask on the introduction of a new power is, what are to be its advantages over existing powers and processes? In regard to gun-cotton, we at once ask, therefore, what are its advantages over gunpowder? Is it stronger? Is it more convenient? Is it cheaper? Why should we give up gunpowder and take to gun-cotton? The answers to these questions categorically will best introduce it to the English reader.

I. Is gun-cotton stronger than gunpowder? The answer to this is, Yes, sixfold stronger.

By this we mean that if we take a given weight of gun-cotton, say four ounces, if we bore a hole $1\frac{1}{2}$ inch in diameter and 3 feet deep, into hard rock or slate, in a quarry, and put 4 ounces of gun-cotton into it, it will occupy about 1 foot of its length, and the aperture being closed in the usual manner, and a matchline led from the charge to the proper distance from which to fire it; and if we next take 24 ounces of best gunpowder, bore a similar hole, and charge it similarly with gunpowder, and close it in the same way; it has been found that, on these being exploded, the 4 ounces of gun-cotton have produced greater effect, in separating the rock into pieces, than the 24 ounces of gunpowder. The answer is, therefore, that in disruptive explosion the strength of gun-cotton is sixfold that of good gunpowder.

But the disruptive or bursting power of gunpowder is not always the quality for which we value it most, nor the service we require of it. In mining rocks, in exploding shells, in blowing up fortresses, this property is what we value, and this work is what we require. But we do not want to burst our fowling-pieces, our rifles, our cannon. On the contrary, we want to use a force that shall project the projectile out of the gun without bursting the gun, without straining the gun beyond a given moderate limit, which it shall be able to endure. We want therefore a service from gun-cotton which shall be the contrary of destructive to, or disruptive of, the chamber in which it does the work of giving motion to the projectile.

This moderated and modified work, gun-cotton can also perform; and it is the modern discovery of General Lenk, which has enabled us to moderate and modify gun-cotton to this gentler service. He discovered how to organize, arrange, and dispose mechanically of gun-cotton in such a way that it should be three times stronger than gunpowder. Accordingly, one of his charges of gun-cotton, weighing 16 ounces, projected a 12-pound solid round shot with a speed of 1,426 feet a second, while a charge of gunpowder of 49 ounces gave the same shot a speed of 1,400 feet a second. One-third of the weight of gun-cotton exceeded, therefore, the threefold weight of gunpowder in useful effect.

II. Is gun-cotton more convenient than gunpowder? This is a larger and more various question than the former, and divides itself into various subdivisions.

It is well known to sportsmen, to soldiers, to artillery-men, that gunpowder fouls a gun. A foul residue of soot, sulphur, and potash soils the inside of the gun after every charge. The gun must, somehow, be cleaned after a discharge; if not it fires worse, recoils more, and ceases to do its best. If the gun be a breech-loading gun its mechanism is dirtied, and works less easily. Gun-cotton deposits no residue, leaves the gun clean and clear, and the utmost it does is to leave a gentle dew of clear water on the inside of the bore, this water being the condensed steam which forms one of the products of its decomposition. Gun-cotton is, therefore, superior to gunpowder in not fouling the gun, a result favourable both to quicker and more accurate firing.

It is further a matter of no slight convenience that gun-cotton makes no smoke. In mines the smoke of gunpowder makes the air unbreathable, and for some time after explosion the miners cannot return to their work. In boring the great tunnel of Mont Cenis through the Alps, the delay from smoke of powder alone will postpone the opening of the line for many months. After a properly-conducted explosion of gun-cotton, the workmen may proceed in their work at once without inconvenience.

In casemates of fortresses, gunpowder fills the casemates with foul smoke, and the men speedily sink under the exertion of quick firing. By using gun-cotton it was ascertained that the men could continue their work unharmed for double the quantity of firing. This is partly attributed to the greater heat, and partly to the foulness of the air produced by gunpowder.

But it is under the decks of our men-of-war, that greatest benefit is likely to arise from gun-cotton. Not only does the smoke of a broadside fill the between decks with hot and foul air, but the smoke of the windward gun blinds the sight, and hinders the aim of the leeward. When there is no smoke, as with gun-cotton, the aim of every gun may be precise and deliberate. The diminished heat between decks will also tell powerfully in favour of gun-cotton. In our armour-plated ships also there is more value in breech-loading guns, than in any other use of artillery. It is one of the necessities of breech-loading mechanism, that it be kept clean, and nothing tends more to derange its perfect action than the greater heat which gunpowder imparts to the gun from which it is fired.

That gun-cotton has the convenience of not heating the gun has been thus proved. 100 rounds were fired in 34 minutes with gun-cotton, and the temperature of the gun was raised 90°. 100 rounds were fired with gunpowder, and triple the time allowed to cool the gun, which nevertheless was heated so much as to evaporate water with a hissing sound, which indicated that its temperature was much above 212°. Under these circumstances the firing with gunpowder had to be stopped, while that with gun-cotton was comfortably continued to 180 rounds.

It is also a matter of practical convenience that gun-cotton, insomuch as it is lighter, can be carried more easily and farther than gunpowder; and it may be wetted without danger, so that when dried again in the open air, it is as good for use as before.

III. We have now to ask—is it cheaper? The answer to this question must be qualified—pound for pound it is dearer; we must therefore judge of its cheapness by its effect, not by weight merely. But where it does six times as much work, it can then be used at six times the price per pound and still be as cheap as gunpowder. As far as we yet know, the prices of gun-cotton and gunpowder are nearly equal, and it is only therefore where the one has advantages and conveniences beyond the other, and is more especially suited for some specific purpose, that it will have the preference. Effective cheapness will therefore depend mainly on which of the two does best the particular kind of duty required of it.

To illustrate how curiously these two powers, gun-cotton and gunpowder, differ in their nature, and how the action of gun-cotton may be changed by mechanical arrangements, we may take one kind of work that is required of both :—If a General want to blow open the gates of a city, he orders an enterprising party to steal up to the gate, with a bag containing 100 lbs. of gunpowder, which he nails to the gate, and by a proper match-line he fires the gunpowder and bursts open the gate. If he nailed a bag of gun-cotton of equal weight in the same place and fired it, the gun-cotton would fail, and the gate would be uninjured, although the 100 lbs. of gun-cotton is sixfold more powerful than the gunpowder. Here, then, gunpowder has the advantage—both weight and effect considered.

But the fault here lies not in the gun-cotton, but the way of using it. If instead of 100 lbs. of gun-cotton in a bag, 25 lbs. had been taken in a proper box made for this purpose, and simply laid down near the gate, and not even nailed to it, this 25 lbs. would shiver the gate into splinters. The bag which suits the powder happens not to suit the gun-cotton.

Gun-cotton is therefore a power of a totally different nature from gunpowder, and requires complete study to know its nature and understand its use. It appears that both gunpowder and gun-cotton have special qualities, and may be peculiarly suited for peculiar uses. It is the duty of a wise people to make use of both to the ends they each suit best, without prejudice arising from the accident of novelty or antiquity.

The nature of gun-cotton requires a double study, chemical and mechanical. It is not like steam, the same substance, whether in the form of ice or water or steam. It is one substance when as gun-cotton it enters the gun, and quite a different one when it has exploded and leaves the gun. Not only are the solids which enter converted into gas, but they form totally new combinations and substances. So that the marvellous changes which the chemist effects by the magic of his art take place in an instant of time, and during that almost inconceivably minute period of time, in a laboratory intensely heated, old substances are dissolved, their material atoms are redistributed, each atom released selects by natural affinity a new partner, these new unions are cemented, and at the end of this prolific instant totally new combinations of matter, forming what we call new substances, issue from the gun. It so happens that of these new substances, formed out of gun-cotton, all are pure transparent gases, while in the case of gunpowder there remain 68 per cent. of solid residue, and only 32 per cent. are pure gases.

It is to chemistry however, that we must look for full and authentic information as to these wonderful changes: first, from the innocent, gentle cotton wool in which our wives and daughters wrap their jewels for soft keeping, into the terrible and irresistible compound of nitric acid and cotton fibre which forms tri-nitro-cellulose, the chemical name of gun-cotton. Chemistry must also tell us how tri-nitro-cellulose is to be turned by heat into transparent explosive gases of such tremendous power.

In short, chemistry has to supply us with the new material, and it is to the science of mechanics that we must look for inventions, of the best way to manipulate and apply it to use for doing the practical work we set it to, in the most effectual, convenient, and economical way.

The chemistry of gun-cotton is therefore the first part of our study of this power, and the mechanics of gun-cotton forms the second.

I.—The Chemistry of Gun-Cotton.*

Although gun-cotton was discovered eighteen years ago by one of the first chemists of the day, Professor Schönbein, and researches on its nature and preparation were almost immediately instituted in this country by Porrett, Teschemacher, Taylor, Gladstone and others, no accurate knowledge of the true constitution and chemical nature of this important material was obtained until Hadow, an English chemist, published in 1854 the result of some valuable investigations by which the mode of formation and composition of gun-cotton were conclusively established.

Cotton, or cellulose as it is termed by chemists, is built up of a certain number of atoms of carbon, oxygen, and hydrogen. Chemistry is scarcely yet able to point out how these atoms are probably arranged; but there appears to be no doubt that some of the elementary particles are so intimately connected with the very existence of cotton, that they cannot be displaced or removed without destroying the very existence of the substance; whilst other atoms, on the contrary, are more loosely held together, and are gifted with a certain mobility which enables them to be taken out altogether without materially altering the outward physical character of the cotton, provided the spaces which these atoms would leave vacant, are immediately filled up by certain other atoms. Now, without entering into the details of chemical formulæ, which would neither interest our readers nor render our meaning more intelligible, we may briefly say that, in ordinary cotton, three atoms of the hydrogen (of which there are ten altogether) are in this loose state of combination, and may be removed and their places filled up by a compound atom of *hyponitric acid* without so far altering the character of the substance as to render the name of cotton inapplicable to it. It may be just mentioned in passing, that it is not necessary that the whole three atoms of hydrogen should be taken out and their places filled up by hyponitric acid; only one or two of them may be so replaced, but as these are inferior for explosive purposes (although of great use to photographers, inasmuch as when dissolved in ether they form collodion), we need

* For this portion of my paper I am indebted to the kindness of Mr. Wm. Crookes, F.R.S.

only direct our attention to the compound with the highest displacement. From its explosiveness and consequent similarity to gun-*powder*, this has been called gun-*cotton*. In scientific language, following the excellent custom adopted by chemists in the nomenclature of organic compounds, a name has been given to it which fully expresses its composition: *cellulose* being the scientific name for cotton, and the prefix *nitro* being added when any of the hydrogen in an organic compound is replaced by hyponitric acid (by no means an uncommon occurrence in organic chemistry), chemists call the product in this instance *tri-nitro-cellulose*, signifying that it is cellulose, in which three equivalents of the hydrogen are replaced by nitrous acid. It is also sometimes called *pyroxilin*, under the impression, we suppose, that by translating a useful English term into barbarous Greek it becomes scientific. This system of pseudo-scientific nomenclature is, unfortunately, too common. If an expressive, convenient, but empirical name be desired, by all means let us have the common English name in popular use. If, on the other hand, a scientific term be required, let us, in the name of all that is scientific, build up this name according to the orthodox rules of science; but we protest against a name like pyroxilin, which leads to nothing but the inference that science is not indigenous to the soil of England.

Most European governments have attempted to utilize gun-cotton in warfare. Soon after its discovery, Messrs. Hall, the well-known gunpowder makers at Faversham, commenced its manufacture upon a considerable scale: their factory had, however, not been long in operation before a very disastrous explosion occurred, by which a number of men lost their lives, and this was ascribed to the spontaneous ignition of the gun-cotton: the manufacture was therefore abandoned in England.

As early as the winter of 1846 a French manufactory was established at the Government Powder Works at Bouchet, near Paris, and much valuable information was obtained respecting the comparative value of gun-cotton and gunpowder; but three disastrous explosions occurring within a year (one taking place in a magazine near which it was believed that no one had been for several days) put a stop, until quite recently, to further experiments.

In Austria, experiments were likewise instituted, and although the committee of the German Confederation pronounced unfavourably upon it, one of the members, General Lenk, devoted himself assiduously to its study, and with such success that the Austrian Government were induced to reconsider their adverse determination. The manufacture was commenced upon a large scale, and above forty batteries of guns were furnished with this agent, and successfully used. The complete supersession of gunpowder by gun-cotton was considered certain, when an explosion, which took place at the Austrian gun-cotton magazines at Limering, again put a stop (to some extent) to its use in artillery. Another Austrian committee, however, reported so favourably on its value, stability, and non-liability to spontaneous explosion, that gun-cotton was again restored to favour.

The very favourable accounts respecting the value of gun-cotton for warlike purposes, which were from time to time received by our government, led to experiments on a considerable scale in this country. The manufacture of this agent is now in full operation both at the Government Powder Works at Waltham Abbey, and also at a large private manufactory at Stowmarket.

The great danger in the case of the early gun-cotton was its liability to spontaneous explosion, and whilst there remained the slightest suspicion of such a possibility, its employment for war purposes was out of the question. The investigations of General Lenk have shown that this accident is due to imperfect preparation, and that by adopting the precautions which he has pointed out, its spontaneous ignition is impossible. It has been very clearly established that the lower nitro-compounds of cellulose, that is, cotton in which only one or two of the atoms of hydrogen are replaced by hyponitric acid, are much more easily decomposed than the compound in which the replacement has proceeded to its fullest extent. Tri-nitro-cellulose, or true gun-cotton, is a remarkably stable compound under all possible atmospheric conditions, but it is by no means easy to ensure the complete conversion of cotton into this body, and it has been shown to be in the highest degree probable that the explosions which put a stop to the early attempts at utilizing gun-cotton were due to its incomplete conversion. The directions given by Schönbein, although successful on the small scale, fail when tried with large quantities, and to General Lenk is due the credit of devising a process of manufacture which gives an absolutely uniform and true chemical compound when working on the largest scale. Ordinary gun-cotton is generally made by saturating cotton-wool with a mixture of one part of concentrated nitric acid and three parts of oil of vitriol, and allowing the mixture to stand at rest for one hour; it is then thoroughly washed and allowed to dry in the air. This process is tolerably successful when only about half-an-ounce of cotton is treated at one time, but it is found to be ineffectual in making a uniform and safe material for war purposes. The most important of the precautions recommended by General Lenk, are, the cleansing and perfect desiccation of the cotton as a preliminary to its immersion in the acids; the employment of the strongest acids obtainable in commerce; the steeping of the cotton in a strong mixture of acids after its first immersion and its partial conversion into gun-cotton; the continuance of the steeping for forty-eight hours; and the thorough purification of the gun-cotton so produced from every trace of free acid: this is secured by its being washed in a stream of water for several weeks. Subsequently a weak solution of potash may be used, but this is not essential. The prolonged continuance of these processes, which would appear superfluous at first sight, is really essential, when we consider that each cotton fibre is a long, narrow, tube, often twisted and even doubled up, and the acid has first to penetrate into the very farthest depths of these tubes, and has afterwards to be soaked out of them. Hence the necessity of time.

It appears that gun-cotton, prepared in this manner, is a true chemical compound, and is not liable to the objections which have been urged against that mixture of compounds which has been usually employed in experiments. The advantages which it possesses may be classed as follows:—

1. It is of uniform composition, and thus the force of the gases generated on explosion may be accurately estimated.

2. It will not ignite till raised to a temperature of 300° F. (as a rule, the temperature must be raised much higher). This is considerably lower than the igniting point of gunpowder, but, being much above the heat of boiling water, it can only occur when artificially produced by means which would render gunpowder itself liable to ignition.

3. It is almost absolutely free from ash when exploded under pressure in a confined space.

4. It has a very marked superiority in stability over other forms of gun-cotton, having been kept unaltered for fifteen years.

One great advantage which gun-cotton possesses over gunpowder, and which ought to have considerable weight in any discussion of their comparative uses for national purposes, is, that gun-cotton is unaffected by water. Gunpowder in a damp atmosphere will soon be completely spoiled, and it cannot afterwards be restored to a serviceable condition without being again submitted to the processes of manufacture, starting almost from the commencement. Gun-cotton, on the contrary, although it gets damp in a moist atmosphere, rapidly returns to its ordinary state when exposed to air of average dryness. Complete immersion in water for an indefinite period has no injurious action on it, for when afterwards dried by exposure to the air, it is as good as ever. The absolute safety which this property would confer upon the magazines of forts and ships cannot be too highly urged; the explosive material could be kept permanently in tanks full of water, in which case a lighted candle or even a red-hot shot would be a harmless visitant. When required for action, a centrifugal drying machine and a hot-water closet would supply the combatants with any quantity at a few hours' notice.

When gun-cotton is ignited in a close vessel, such as a shell or the chamber of a gun, it is at once converted into certain gases, the principal being carbonic oxide, carbonic acid, nitrogen, light carburetted hydrogen, hydrogen, and steam. The introduction of the hyponitric acid, a compound containing a large excess of oxygen, gives to the cotton a sufficient amount of this gas to reduce it completely to the state of vapour; but although only gases are produced, there is not enough oxygen for their complete combustion. About 40 per cent. are inflammable, and produce a bright flash when they emerge into the air from the mouth of the gun.

II.—The Mechanics of Gun-cotton.

The mechanical application of gun-cotton may be considered to be due exclusively to Major-General Lenk, of the Austrian service. Pure gun-cotton becomes either a powerful explosive agent, or a docile performer of mechanical duty, not according to any change in its composition, or variation in its elements or their proportions, but according to the mechanical structure which is given to it, or the mechanical arrangements of which it is made a part. It was General Lenk who discovered that structure was quality, and mechanical arrangement the measure of power, in gun-cotton; and in his hands, a given quantity of the same cotton becomes a mild, harmless, ineffectual firework, a terrible, irresistible, explosive agent, or a pliable, powerful, obedient workman.

The first form which General Lenk bestowed on gun-cotton was that of a continuous yarn or spun thread. Gunpowder is carefully made into round grains of a specific size. Gun-cotton is simply a long thread of cotton fibre, systematically spun into a yarn of given weight per yard, of given tension, of given specific weight. A hank of a given length is reeled, just like a hank of cotton yarn to be made into cloth, and in this state gun-cotton yarn is bought and sold like any other article of commerce.

This cotton yarn converted into gun-cotton may be called, therefore, the raw material of commerce. In this form it is not at all explosive in the common sense of the word. You may set fire to a hank of it, and it will burn rapidly with a large flame; but if you yourself keep out of the reach of the flame, and keep other combustibles beyond reach, no harm will happen, and no explosion or concussion will result. If you lay a long thread of it round your garden walk at night, disposing it in a waving line with large balls of gun-cotton thread at intervals, and light one end of the thread, it will form a beautiful firework, the slow lambent flame creeping along with a will-o'-th'-wisp-looking light, only with a measured speed of 6 inches per second, or 30 feet a minute; the wind hastening it or retarding it as it blows with or against the line of the thread. This is the best way to commence an acquaintance with this interesting agent.

Care must be taken not to become too familiar with gun-cotton even in this harmless and playful guise; cotton dresses will readily catch fire from it, and it should not be treated with less care to keep fire from it than gunpowder. In one respect it is less liable to cause danger than gunpowder. Grains of powder are easily dropped through a crevice, and may be sprinkled about in a scarcely noticeable form, but a hank of gun-cotton is a unit, which hangs together and cannot strew itself about by accident.

The *second* form of gun-cotton is an arrangement compounded out of the elementary yarn. It resembles the plaited cover of a riding-whip; it is plaited round a core or centre which is hollow. In this form it is match-line, and, although formed merely of the yarn plaited into a round hollow cord, this mechanical arrangement has at once conferred on it the quality of speed. Instead of travelling as before only 6 inches a second, it now travels 6 feet a second.

The *third* step in mechanical arrangement is to enclose this cord in a close outer skin or coating, made generally of India-rubber cloth, and in this shape it forms a kind of match-line, that will carry fire at a speed of from 20 to 30 feet per second.

It is not easy to gather from these changes what is the cause which so completely changes the nature of the raw cotton by mechanical arrangement alone. Why a straight cotton thread should burn with a slow creeping motion when laid out straight, and with a rapid one when wound round in a cord, and again much faster when closed in from the air, is far from obvious at first sight; but the facts being so, deserve mature consideration.

The cartridge of a common rifle in gun-cotton is nothing more than a piece of match-line in the second form enclosed in a stout paper-tube, to prevent it being rammed down like powder. The ramming down, which is essential to the effective action of gunpowder, is fatal to that of gun-cotton. To get useful work out of a gun-cotton rifle, the shot must on no account be rammed down, but simply transferred to its place. Air left in a gunpowder barrel is often supposed to burst the gun; in a gun-cotton barrel, it only mitigates the effect of the charge. The object of enclosing the gun-cotton charge in a hard strong pasteboard cartridge, is to keep the cotton from compression and give it room to do its work.

It is a *fourth* discovery of General Lenk, that to enable gun-cotton to perform its work in artillery practice, the one thing to be done is to "give it room." Don't press it together—don't cram it into small bulk! give it at least as much room as gunpowder in the gun, even though there be only one-third or one-fourth of the quantity (measured by weight). 1 lb. of gun-cotton will carry a shot as far as 3 or 4 lbs. of gunpowder; but that pound should have at least a space of 160 cubic inches in which to work.

This law rules the practical application of gun-cotton to artillery. A cartridge must not be compact, it must be spread out or expanded to the full room it requires. For this purpose, a hollow space is preserved in the centre of the cartridge by some means or other. The best means is to use a hollow thin wooden tube to form a core; this tube should be as long as to leave a sufficient space behind the shot for the gun-cotton. On this long core the simple cotton yarn is wound round like thread on a bobbin, and sufficiently thick to fill the chamber of the gun; indeed, a lady's bobbin of cotton thread is the innocent type of the most destructive power of modern times—only the wood in the bobbin must be small in quantity in proportion to the gun-cotton in the charge. There is no other precaution requisite except to enclose the whole in the usual flannel bag.

The artillerist who uses gun-cotton has therefore a tolerably simple task to perform if he merely wants gun-cotton to do the duty of gunpowder. He has only to occupy the same space as the gunpowder with one-fourth of the weight of gun-cotton made up in the bobbin as described, and he will fire the same shot at the same speed. This is speaking in a general way, for it may require in some guns as much as $\frac{1}{3}$ of the weight of gunpowder and $\frac{1}{10}$ the bulk of charge to do the same work; a little experience will settle the exact point, and greater experience may enable the gun-cotton to exceed the performance of the gunpowder in every way.

The *fifth principle* in the use of gun-cotton is that involved in its application to bursting uses. The miner wants the stratum of coal torn from its bed, or the fragment of ore riven from its lair; the civil engineer wishes to remove a mountain of stone out of the way of a locomotive engine; and the military engineer to drive his way into the fortress of an enemy, or to destroy the obstacles purposely laid in his way. This is a new phase of duty for gun-cotton—it is the work of direct destruction. In artillery you do not want to destroy directly, but indirectly. You don't want to burst your gun, nor even to injure it; and, we have seen, in order to secure this, you have only to give it room.

The fifth principle, therefore, is, to make it destructive—to cause it to shatter everything to pieces which it touches, and for this purpose you have only to deprive it of room. Give it room, and it is obedient; imprison it, and it rebels. Shut up without room, there is nothing tough enough or strong enough to stand against it.

To carry this into effect, the densest kind of gun-cotton must be used. It must no longer consist of fine threads or hollow textures wound on roomy cores. All you have to do is to make it dense, solid, hard. Twist it, squeeze it, ram it, compress it; and insert this hard, dense cotton rope or cylinder or cake in a hole in a rock, or the drift of a tunnel, or the bore of a mine; close it up, and it will shatter it to pieces. In a recent experiment, 6 ounces of this material set to work in a tunnel not only brought down masses which powder had failed to work, but shook the ground under the feet of the engineers in a way never done by the heaviest charges of powder.

To make gun-cotton formidable and destructive, squeeze it and close it up; to make it gentle, slow, and manageable, ease it and give it room. To make gunpowder slow and gentle, you do just the contrary: you cake, condense, and harden it to make it slow, safe for guns, and effective.

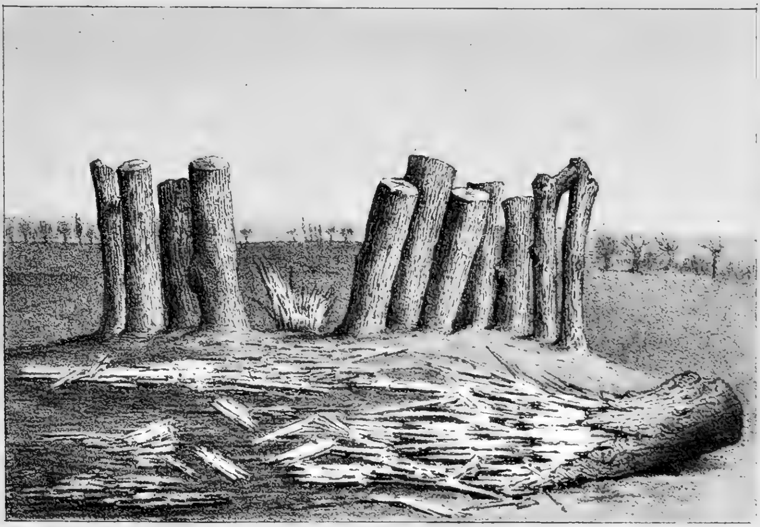
To carry out this principle successfully, you have to carry it even to the extreme. Ask gun-cotton to separate a rock already half-separated, it will refuse to comply with your request. Give it a light burden of earth and open rock to lift, it will fail. If you want it to do the work, you must invent a ruse,—you must make believe that the work is hard, and it will be done. Invent a difficulty and put it between the cotton and its too easy work, and it will do it. The device is amazingly successful. If the cotton have work to do that is light and easy, you provide it with a strong box, which is hard to burst, a box of iron for example; close a small charge, that would be harmless, in a little iron box, and then place that box in the hole where formerly the charge exploded harmless, and in the effort it makes to burst that box, the whole of the light work will disappear before it.

Of the effect of such an explosion, an illustration accompanies this paper. The two drawings represent two views of a stockade, in close contiguity to which a charge of 25 lbs. of gun-cotton, placed in an iron box, was employed, and the consequences will be seen in the two rent and shattered trees, the largest 20 inches in diameter, which were not only removed from their places, but by some unexplained action shattered throughout into matchwood. This explosion was the first trial of English-made gun-cotton, and was made at Stowmarket, in spring.

It is, therefore, the nature of gun-cotton to rise to the occasion and to exert force exactly in proportion to the obstacle it encounters. For destructive shells this quality is of the highest value. You can make your shell so strong that nothing can resist its entrance, and when arrived at its destination no shell can prevent its gun-cotton charge from shivering it to fragments.

These are the main principles in the mechanical manipulation of gun-cotton which will probably render it for the future so formidable an instrument of war. Resistances too great for gunpowder only suffice to elicit the powers of gun-cotton. On the other hand, in its elementary state as the open cotton yarn, it is playful, slow, gentle, and obedient; there is scarcely any mechanical drudgery you can require of it that it is not as ready and fit to do as steam, or gas, or water, or other elementary power.

In conclusion, I may be asked to say as a mechanic what I think can be the nature and source of this amazing power of gun-cotton. In reply let me ask, Who shall say what takes place in that pregnant instant of time when a spark of fire enters the charge, and one-hundredth part of a second of time suffices to set millions of material atoms loose from fast ties of former affinity, and leaves them free every one to elect his mate, and uniting in a new bond of affinity, to come out of that chamber a series of new-born substances? Who shall tell me all that happens then? I will not dare to describe the phenomena of that pregnant instant. But I will say this, that it is an instant of intense heat—one of its new-born children is a large volume of steam and water. When that intense heat and that red-hot steam were united in the chamber of that gun and that mine, two powers were met whose union no matter yet contrived has been strong enough to compress and confine. When I say that a gun-cotton gun is a steam-gun, and when I say that at that instant of intense heat, the atoms of water and the atoms of fire are in contact atom to atom, it is hard to believe that it should not give rise to an explosion infinitely stronger than any case of the generation of steam by filtering the heat leisurely through the metal skins of any high-pressure boiler.



from Photographs. M & N Hanhart Imp De Wilde lith.

EXPLOSIVE EFFECTS OF THE FIRST CHARGE OF ENGLISH MADE GUN COTTON

(Two views of the Stockade.)

BRACKISH-WATER FOSSILS OF CRETE.

Being Illustrations of the Characters of Fluviatile, Lacustrine, and Estuarine Formations.

By H. M. JENKINS, F.G.S., Assistant-Secretary of the Geological Society.

THE Grecian Archipelago and the surrounding mainland have a truly classic interest for the Geologist, not so much on account of their geographical position and ancient fame, as because they were the scenes of some of the most famous labours of the late Professor Edward Forbes, a naturalist who, in his brief but brilliant career, was enabled, chiefly through his investigations in these regions, to throw the bright light of genius over some of the most intricate paths of palæontological research, and who thus invested the eastern portion of the Mediterranean with a far greater interest to the geologist than it otherwise ever would have possessed. Still it must not be supposed that the region is barren of facts outside the common course of geological phenomena, for, as was shown by Professor Forbes, the fresh-water and estuarine strata which occur there contain fossils exhibiting remarkable modifications of form caused by the more or less adverse influences of the conditions under which they lived.

The fossil shells which have given rise to this paper, and which are figured in the Plate, and described in the Appendix, were submitted to my examination by Capt. T. Spratt, R.N., C.B., F.G.S., who was the companion of Professor Edward Forbes in a great portion of his travels in Asia Minor and the regions round about, and conjoint-author with him of the 'Travels in Lycia;' and he is now busily engaged in bringing out a work on the Island of Crete, which will doubtless add to his already high reputation as a geologist.

Of the other observers who have travelled in these regions, and have contributed to our knowledge of their geology, I may mention Mr. Hamilton, F.R.S., now President of the Geological Society, and his fellow-traveller, the late Hugh Strickland, who were the first to explore geologically these classic countries. We are also much indebted to M. Tchihatcheff and M. Raulin, whose papers have been published in the 'Bulletin de la Société Géologique de France.'

The ancient Lake of the Eastern Mediterranean.—One of the principal points brought forward by Captain Spratt, in his several papers, is that the Eastern portion of the Mediterranean, including Greece, parts of Asia Minor, and probably the north-eastern extremity of Africa, was at some distant epoch in the Tertiary period, the site of a huge fresh-water lake; but the precise geological date at which it existed has not yet been satisfactorily made out, though it probably coincided with that of the deposition of the estuarine strata about to be noticed.

Many years ago, Messrs. Hamilton and Strickland described a series of lacustrine beds in various parts of Asia Minor, where it appears to be the formation most commonly met with in the low grounds; while Captain Spratt has given descriptions of similar strata occurring near Smyrna, and in Lycia, as well as in the Islands of Samos, Rhodes, Cos, Cerigo, &c.; but there is some confusion as to their probable age. Captain Spratt originally considered all of them to be of Eocene date, it being borne in mind, however, that when that opinion was published, the term 'Eocene' included what is now known as Lower Miocene, and referred to under that name in these pages. With the assistance of Professor Forbes, this opinion was afterwards somewhat modified, the Smyrna beds being still retained as Eocene (=Lower Miocene), but the Lycian strata, as well as those of Cos and Rhodes, being considered newer. To the supposed age of these newer fresh-water beds I shall have occasion to refer presently at some length, as it bears very importantly upon the age of some of the fossils under consideration.

Geology of the Eastern Mediterranean Region.—The Tertiary beds of Greece, of the Islands of the Archipelago, and of Asia Minor, are generally found reposing on the Apennine Limestone, or Scaglia, which is of Cretaceous age, or else abutting against it, the Scaglia in such cases forming the high land of the interior, and the Tertiary beds skirting it and facing the sea, and often extending to the coast. Some of these Tertiary strata contain marine remains, others include fresh-water (probably lacustrine) organisms, and the fossils figured in the Plate were probably from a brackish-water lake or estuary.

For the better understanding of the subject it will, first of all, be necessary to give a synopsis of the argument which has been supposed to prove that the fresh-water beds of the Valley of the Xanthus, of Cos, and of Rhodes, are of Pliocene age, and for this purpose I must call in the aid of Professor Forbes and Captain Spratt.*

Relative Age of the Marine and Fresh-water Strata of Lycia.—In the Valleys of Xanthus and Kassabar there is a fresh-water formation supposed to be more recent than certain marine sandy strata, containing shells which also occur in the Upper Miocene beds of Bordeaux, Touraine, &c.; and the manner in which this is apparently proved may be thus stated. The valley of Xanthus is bounded on each side by hills of highly-inclined Scaglia, upon which rests conformably a slightly newer deposit termed 'Macigno.' The floor of the valley consists of horizontal beds of marl, capped by conglomerate, and containing fresh-water fossils. High up on the hill-sides are patches of the marine formation in question, dipping west at a high angle, and it has been assumed to be the older, entirely on account of its being inclined, while the fresh-water beds are horizontal; the order of events being—(1) its deposition horizontally over where the valley now is, (2) its tilting-up and entire denudation, and (3) the deposition of fresh-water beds in its place. Granting the assumed basis of the argument, the reasoning is perfectly correct.

Furthermore, the Xanthus fossils are some of them identical with those occurring in the island of Cos, in a fresh-water formation forming

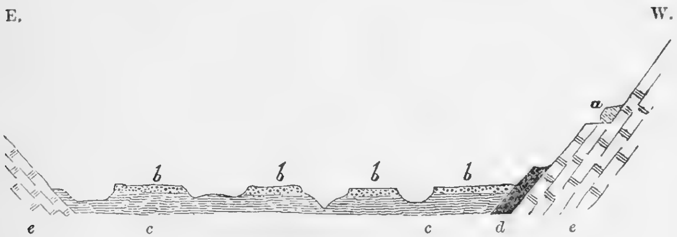
* 'Travels in Lycia,' vol. ii. p. 175.

the wall of a series of marine beds containing newer Pliocene fossils; so that the fresh-water beds must be the older, and as, granting the correctness of the former argument, they have been proved to be newer than the Upper Miocene, they must, in that case, hold an intermediate position, and on these grounds they have been termed Older Pliocene.

Thus far, excluding the scepticism, I have followed Professor Forbes and Captain Spratt, who enunciated the above (apparently) convincing proof of the age of the Cos and Xanthus fresh-water beds in the 'Travels in Lycia' already referred to. From a very brief consideration of the argument, the principle on which it is based will make itself apparent to everyone. The object is to fix a limit in both directions to the age of the strata, or, to use the original terms, to find an 'ante-date' and an 'after-date,'—a process often resorted to by the inquisitive in their efforts to discover the ages of their friends!

If we inquire a little more closely into the basis of the argument, namely, that the inclined position of the marine strata is suggestive of their greater age (which is altogether assumed), we shall find, on reference to the section given below, that they *dip the wrong way!*—and thus a doubt is cast upon the whole of the reasoning. The following explanation will make my meaning clear: suppose the Scaglia and Macigno to be more or less horizontal, and the marine formation to be deposited conformably on it, then suppose the valley to be formed by the elevation of the Scaglia on each side, and to be rendered deeper by the erosion of the marine strata, it is evident that the remaining patches of the marine formation would dip conformably with the Scaglia, not at nearly right angles to it, as in the following section:—

Section across the Valley of Xanthus.—(After Forbes and Spratt.)



a Marine sandy strata (Miocene), dipping *from* the centre of the valley.
b. Conglomerate. *c.* Marl (freshwater). *d.* Macigno.
e. Scaglia (Cretaceous) dipping *towards* the centre of the valley.

On the other hand, if the Scaglia were upheaved, as it evidently was, before the deposition of the marine beds, it is quite impossible that the latter could have been deposited horizontally and afterwards tilted up, because the Scaglia must have been affected at the same time; and if we assume that its dip was lower when the marine beds were formed, the latter must have been deposited almost vertical, which cannot be credited for a moment; and if the marine Tertiaries were deposited in a horizontal position, the Scaglia must formerly have been nearly vertical. Indeed, it is evident that the apparent dip of the marine beds is due to false-bedding, and not to elevation at all; consequently it is no indication of their being older than the horizontal fresh-water strata.

Again, supposing that the marine beds were the older, they must once have filled up the valley. By what manner of water-action could they have been so completely washed away that no trace of them exists anywhere beneath the fresh-water formation, and only small patches are left high up on the hill-sides, where they could least of all be expected?

Considering all the difficulties in the way of the marine beds being the older, and that there is no physical reason why they should not be the newer (granting the apparent dip to be due to the false-bedding), we may legitimately compare the fossils of the Cos and Xanthus fresh-water beds, with the shells figured in the Plate, without taking into account their supposed Pliocene age, to which view, it will be found, their evidence is entirely antagonistic. It may be remarked, however, that if the fresh-water strata are the older, the lowest bed, in which occur the same genera as Captain Spratt has obtained from Crete, must, according to its fossils, either be very low down in the Upper Miocene, or must belong to the Lower Miocene: perhaps it does not matter which we consider it; but the point I shall now attempt to establish is that our Cretan fossils are of the same age.

Geological Age of the Fossils under consideration.—A glance at the following lists will show that of those from Cerigo, all, with the exception of *Cerithium Cytherorum* (a new species), occur in the Upper Miocene of Europe, while two began life earlier. The balance of evidence is therefore strongly in favour of the Cerigo fossils being Upper Miocene; that is to say, of the age of the Vienna and Bordeaux Basins. The marine formation in Crete, described by M. Raulin, and said to be of Miocene age, may possibly belong to the same set of strata, though his list does not include any of our species, which are less decidedly marine than those enumerated by him.

The Cretan specimens being, however, all different from those of Cerigo, with one exception, require further discussion. *Melanopsis buccinoidea*, the only species common to both sets of fossils, is also one of those which appeared first in strata older than the Upper Miocene, and with it is associated in Crete *Cerithium Lamarckii*, which began life in Eocene times and extended up into the Lower Miocene, but which has not been found in newer strata. On the other hand, we have *Melanopsis Bouei*, representing the Upper Miocene period, and a species of *Unio*, allied to *Unio litoralis*, which tells us very little concerning its age. The remaining species, three in number, are new, and one of them presents some remarkable modifications of form, so that it is rather difficult to form a correct idea of their geological date.

The genus *Unio* contains very many species, resembling one another so closely as to render it very difficult to distinguish them, especially in the fossil state, so that very little reliance can be placed on them as indicative of the age of Tertiary strata. *Melanopsis buccinoidea*, as we have seen, furnishes no clue to the age of beds in which it occurs, its range being so extended. *Cerithium Lamarckii*, on the contrary, is a well-known shell, which occurs abundantly in Lower Miocene strata, and is found also in the Eocene "Sables de Beauchamp," so that its occurrence would appear to stamp the age of the deposit as Lower Miocene or older, and to the period named I am inclined to refer it, though it is not impossible that a larger collection of shells may prove it to be somewhat newer. But the great difference between these shells and recent species renders it impossible that the deposit should be Pliocene, as has been supposed.

It by no means follows, however, that there is no more recent formation in Crete; on the contrary, M. Raulin, in a paper on the geology of Crete,* speaks of a lacustrine limestone above a marine formation; and a late lacustrine deposit occurring in the plains in the interior of the island furnished him with the lower jaw of a *Hippopotamus*.

The so-called lacustrine formation of Rhodes contains species of *Neritina* and *Melanopsis*, the latter being *M. Bouei*; with it occurs *Cerithium plicatum*, an associate of *C. Lamarckii* in the Paris and Mayence basins. Although the occurrence of *Cerithium plicatum* is, of itself, not antagonistic to the Upper Miocene age of the strata, yet, when associated with *C. Lamarckii*, it seems reasonable to consider them, for the present at least, as Lower Miocene, especially as the only true Upper Miocene species occurring with them is *Melanopsis Bouei*, and the only recent species is *M. buccinoidea*, which occurs in great numbers in Lower Miocene strata also. The only obstacle to the Upper Miocene age of the beds is, in fact, the occurrence of *Cerithium Lamarckii*; and, although there is no reason why that species may not occur higher in the series, yet as it has not been found in that position hitherto, and as the evidence is at present strongly in favour of its Lower Miocene age in Crete, we must consider it for the present limited to Eocene and Lower Miocene strata.

Malformed Shells.—The fresh-water beds of Rhodes are admitted to be of the same age as those of Cos and Xanthus, some species of shells being common to the three localities, and the remarkable *Neritina abnormis* (Figs. 7*a* to 7*e* of the Plate) from Crete being very near the *Neritina* from Cos figured by Professor Forbes,† if not identical with it. The specimens from both islands exhibit the same kind of malformation, showing that the faunæ of both series of strata lived under similar conditions, which appear to have been unfavourable to some of the species

On examination, it will be seen that the older the specimen, the more distorted does it appear, and the larger are the keels on the whorls, and that, at last, tubercles and even spines spring from them. So in Figs. 8*a* to 8*c*, representing a *Unio*, the same kind of result is seen in the great thickness of the shell, and the small size of one of the specimens, and in Figs. 4*a* to 4*c* in the comparative coarseness of the ribs of *Melanopsis Bouei*. The *Neritina* represented in Figs. 6*a*

* Bull. Soc. Géol. de France. Deuxième Série, vol. xiii.
† 'Travels in Lycia,' vol. ii. p. 203.

to 6*d* has escaped this malformation, to a great extent, but still it is not always quite free from distortion.

But the most remarkable shell "cheated of feature by dissembling nature" is shown in Figs. 3*a* and 3*b*; it is turned the wrong way, and this circumstance, with its peculiar ornament, gives it such a singular appearance, that out of twenty shells spread out on a table, a conchologist would certainly take up this one first, as I have verified by experiment. It seems to defy determination. There are two specimens in Captain Spratt's collection, so that its reversal is not accidental, but, with its thickness and coarse ornament, is apparently due to its having lived under unfavourable circumstances. The species is certainly new, and I have called it *Melania* (?) *anomala*, though I am by no means sure of its genus.

These monstrous kinds of growth are interesting on many grounds, and especially so in relation to the mode of formation of the deposit in which they occur. Professor Forbes and Captain Spratt described such malformed shells from Cos several years ago in the 'Travels in Lycia;' but some of them belonged to the genus *Paludina*, and others, as in this case, to the genera *Neritina* and *Melanopsis*. The Cretan specimens that exhibit abnormal characters belong to the two last-named genera, and to the bivalve genus *Unio*; but the *Cerithia*, which cannot live in fresh water, are quite normal in appearance.

Malformation as a Test of Habitat.—It is easy to see that malformations of this kind may furnish an important clue to the origin of a formation; for instance, in this case, the most truly marine genus is represented by species exhibiting normal characters, while the more fresh-water genera are distorted; thus it appears impossible to assign a purely fresh-water origin to the deposit, and we shall presently see that this conclusion is borne out by independent arguments.

Nearly fifty years ago, M. Beudant proved by experiment, that of the mollusks which inhabit fresh water, those only which had the power of shutting off all communication between themselves and the water they lived in could resist the action of brackish or salt water; that is to say, only bivalves and operculated univalves could exist at all under such circumstances. Upon *à priori* grounds it is allowable to extend this law, for certain pulmoniferous gasteropods are operculated; but, as they cannot breathe without rising to the surface, and as that process entails repeated contact with the noxiously salt water, it is but reasonable to conclude that they could not long survive such a disagreeable necessity. We may therefore say that all pulmoniferous gasteropods and all non-operculated fresh-water gasteropods are unable to live in salt or brackish water.

But although these bivalve and operculated univalve mollusks could resist the action of salt water for a time, M. Beudant found that even the latter could only live permanently if the water contained not more than 4 *per cent.* of saline matter, and that even this small quantity was sufficient to kill the bivalves after a short time; hence arises the paucity of shells of the genera *Unio*, *Cyclas*, &c., in brackish water deposits.

It will now be possible to discuss fairly the probability of the fossils in question having been deposited in a lake or an estuary, and this discussion is the more desirable, because the more or less fresh-water formations of Asia Minor, &c., have often been treated of as necessarily lacustrine. The only circumstances necessary to remember are: (1) that the following remarks do not refer to Cerigo, the fossils from thence being normally estuarine; and (2) that in Crete the most essentially salt-water genera are represented by species normal in character, while the fluviatile genera are represented by distorted species.

But to enable us to decide whether we have been dealing with a marine, an estuarine, a fluviatile, or a lacustrine formation, it is now necessary to discuss the distinctive characters of these classes of deposits, chiefly from a palæontological point of view.

Distinctive Characters of Lacustrine, Fluviatile and Estuarine Deposits.—Purely fresh-water strata are nearly always lake-deposits, because a river seldom deposits in its own bed, and when it does, the deposit is so insignificant, that it is rarely preserved; while, on the other hand, the deposit of a river at its mouth, that is, a delta, contains brackish-water shells, generally mixed with those of fluviatile and terrestrial origin. Again, a lake may be more or less brackish, or even absolutely salt; and a lagoon, which is but another name for a lake connected with a larger body of water, may be subject to periodical irruptions of salt water. Thus there are many contingencies to be guarded against in deciding as to the lacustrine or estuarine origin of a series of beds, supposing the fossils contained in them to exhibit characters not antagonistic to the presence of a certain quantity of salt water, especially in the region under consideration, where lagoons are so abundant; but very little difficulty exists if the shells happen to be purely freshwater and normal in character. Of course, there is this difference between a lake and a river, that whereas the water in the former is more or less stagnant, that in the latter is in motion; but a deposit from a river into a lake would yield evidence of both running and stagnant water, and, unfortunately, shells afford but little evidence as to their fluviatile or lacustrine origin. It would, however, be strange indeed if the fossils of a true lacustrine deposit did not consist, to a certain extent, of the shells of pulmoniferous mollusks; and inasmuch as there is not a single shell belonging to that group amongst the fossils under consideration, the theory of a fresh-water lake cannot well be accepted.

Nature of the Crete Deposit.—All the fossil genera under notice from Crete, excepting the genus *Unio*, have existing species which live in brackish water, or even in the sea, so that they are not antagonistic to the estuarine nature of the deposit, though they are equally favourable to its being a salt-lake formation; but as some of the genera cannot exist in fresh water, the beds cannot have been deposited in a fresh-water lake. Again, *Neritina* and *Melanopsis* are essentially the inhabitants of running water, and the genus *Unio* is just as essentially fresh water, therefore if the fossils presented no abnormal characters, the only rational conclusion would be that the Crete formation is a deposit from a river in an estuary.

But we have seen that one species of *Neritina* is keeled and tuberculated, while another presents ordinary characters, that the *Unio* is unnaturally thick, and, except one specimen, very much stunted, while the most abundant species of *Melanopsis* is represented both by small specimens normal in character, and by large examples unnaturally coarse and ribbed, to say nothing of the wonderful *Melania*. How, therefore, can we account for the entombment of species which lived under normal conditions in association with specimens of the same and other species that evidently lived under circumstances not quite suited to them? Bearing in mind that the normal specimens belong both to fresh-water and estuarine genera, and that the abnormal ones are wholly fresh-water, as well as the fact that all of them could exist in brackish water, being either operculated gasteropods or bivalves, and not belonging to purely fresh-water genera, it appears to me that the only way of accounting for the association is by supposing that the deposit was formed in a lagoon, which was subject to occasional irruptions of salt water, and into which a river flowed.

This conclusion is very similar to that arrived at by Professor Forbes and Captain Spratt respecting the Cos fossils, only that they assumed the lagoon to be at first quite fresh, and to have become gradually saline, and they did not call in the aid of a river; but the occurrence of the *Unio* and of normal and abnormal specimens of *Neritina*, &c., appears to render the latter device necessary in this case. In the lagoon, all the species could exist for a time, after having been carried down by the river, and thus the abnormalities described may have been produced.

APPENDIX.

I.—Descriptions of New Species from Crete.

1. *Neritina abnormis*, mihi. Figs. 7*a* to 7*e*.

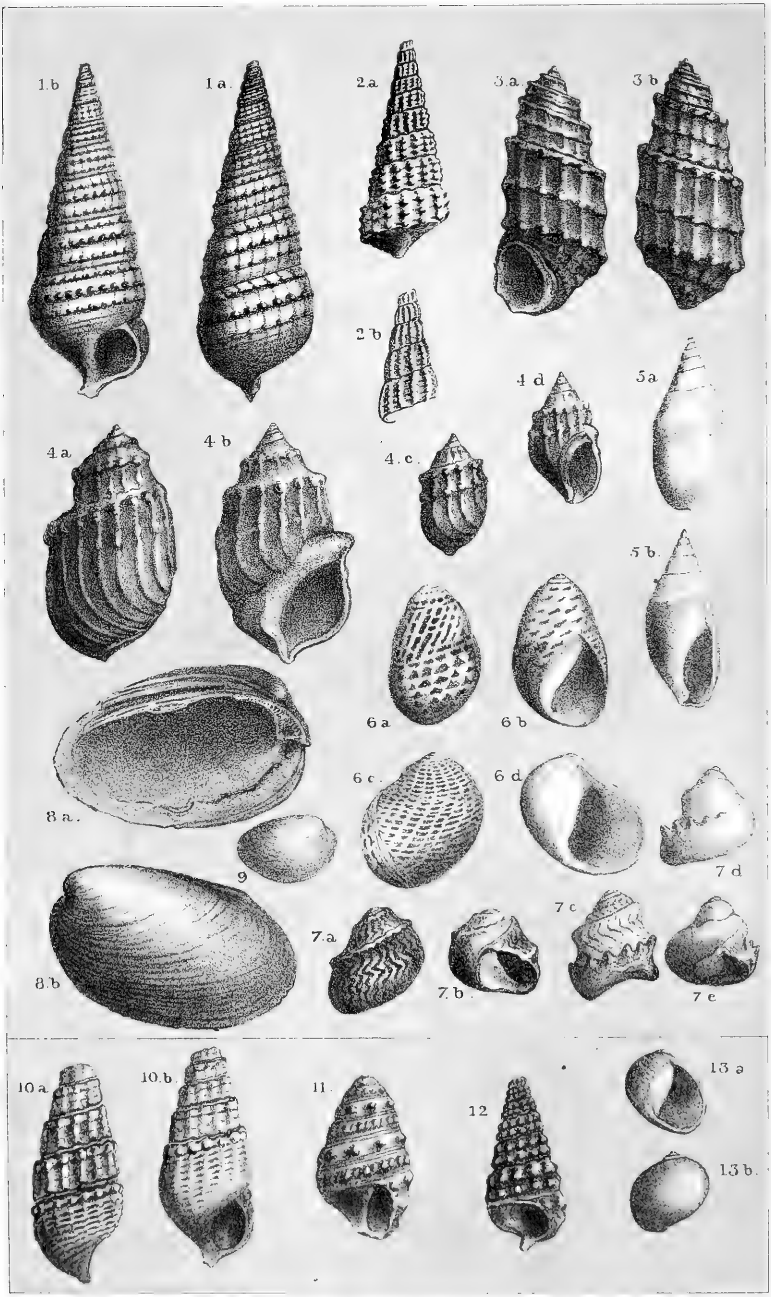
Shell broadly ovate, trochiform, ornamented with brownish zig-zag longitudinal lines or bands; whorls three, crowned by a broad cord-like keel, and with a thinner and sharper ridge in the middle, often corded or crenate, and sometimes tuberculated or irregularly spiniferous, separated from the upper keel by the concave upper portion of the whorl. Mouth in a plane nearly at right angles to the axis, more or less semilunate in form; inner lip concave, smooth, with a broad callosity covering the base of the shell, and becoming very thick and encroaching on the mouth in old specimens.

2. *Neritina Spratti*, mihi. Figs. 6*a* to 6*d*.

Shell ovate, smooth, ornamented with many blackish spots, more or less regularly arranged; whorls three or four, declining above, sometimes compressed in the middle, convex at the base. Spire depressed, blunt. Mouth oblique, irregularly semilunate in form; inner lip concave, callous, minutely dentate

3. *Melania? anomala*, mihi. Figs. 3*a*, 3*b*.

Shell thick, reversed, turreted, ovate, somewhat obtuse at the apex; whorls about seven, slightly convex, transversely and longitudinally ridged; transverse ridges coarse and blunt, obsolete on the uppermost whorls, and gradually increasing in number, from two on the third whorl to four on the body-whorl; longitudinal ridges obsolete on the upper whorls and becoming gradually more apparent on the lower; they are the same distance apart as the transverse ridges, which they



H M Jenkins del. M & N Hanhart imp. De Wilde lith.

BRACKISH WATER FOSSILS OF CRETE & CERIGO cross at right angles, forming a tubercle at the point of intersection. Base of the shell similarly ornamented and slightly umbilicate. Mouth oval; columella thickened; inner lip callous above; callosity flat, thin, spreading over part of the base of the shell above the small umbilicus.

4. *Cerithium recticostatum*, mihi. Figs. 2*a*, 2*b*.

Shell turreted, acute; whorls numerous, slightly convex, ornamented with three sharp transverse ridges, crossed at right angles by about ten straight, sharp, very prominent, and almost lamelliform varices, which are slightly tuberculated at the point of crossing, and also just below the suture, where they are crossed by a fourth and very small longitudinal ridge. Mouth oval, effuse at the base, where the peristome is prolonged into a pointed spout.

5. *Unio Cretensis* mihi. Figs. 8*a to* 8*c*.

Shell very thick and coarse, sub-rhomboidal, with the upper margin convex, and the lower almost straight; anterior extremity rounded, scarcely projecting beyond the umbo; posterior extremity obliquely projecting, very convex, almost pointed, ending above in a sharp angular ear; umbo prominent, scarcely eroded. Hinge-teeth and lamellæ very thick and projecting; anterior muscular impression very deep, much deeper than the posterior.

II.—Description of a New Species from Cerigo.

Cerithium Cytherorum, mihi. Fig. 11.

Shell turreted, acute; whorls numerous, convex, ornamented with two convex transverse bands, which are separated by a sharply-defined shallow groove, and are tuberculated where crossed by the varices; varices curved, broad, not very distinct; suture neatly impressed, slightly undulated. Mouth small, nearly round; columella callous, twisted, and somewhat produced, oblique. Base of the shell ornamented with about five parallel ridges crossed by distinct lines of growth.

EXPLANATION OF PLATE.

Fossils from Crete.

Figs. 1*a*, 1*b*.—*Cerithium Lamarckii*. Magnified 2 diameters. From the plain of Arkadia.
„ 2*a*.—*C. recticostatum*. Natural size. From Kherisoniso.
„ 2*b*.—*C. recticostatum*, var. Natural size. From Kherisoniso.
„ 3*a*, 3*b*.—*Melania? anomala*. Magnified 2 diameters. From Kherisoniso.
„ 4*a to* 4*c*.—*Melanopsis Bouei*. Magnified 2 diameters. From Kherisoniso.
„ 5*a*, 5*b*.—*Melanopsis buccinoidea*. Natural size. From the Plain of Arkadia. This species also occurs in Cerigo.
„ 6*a to* 6*d*.—*Neritina Spratti*. Magnified 2 diameters. From Kherisoniso.
„ 7*a to* 7*e*.—*N. abnormis*. Magnified 2 diameters. From Kherisoniso.
„ 8*a to* 8*c*.—*Unio Cretensis*. Natural size. From Kherisoniso.

Fossils from Cerigo.

Figs. 9*a*, 9*b*.—*Cerithium plicatum*. Natural size.
„ 10.—*C. doliolum*. Magnified 2 diameters.
„ 11.—*C. Cytherorum*. Magnified 2 diameters.
„ 12*a*, 12*b*.—*Neritina fluviatilis*. Magnified 2 diameters.

ON THE HISTORY AND USES OF THE OPHTHALMOSCOPE.

By Thomas Nunneley, F.R.C.S.E., &c.

Though the present age may not be so distinguished for any very brilliant discovery or startling scientific invention as were some of those which are gone by, it may be doubted if there has ever been a period in the world's history in which work likely to advance knowledge and benefit mankind was more heartily, honestly, or generally pursued than at the present day. If the rewards have not been so great to one or two individuals as to overshadow and obscure the gleanings of all the other labourers, the progress made in precise knowledge and the adoption of scientific precision has certainly never been more marked. The result is a steady progress, even in those departments of knowledge which heretofore have been considered as rather speculative than positive, or as belonging more to art than to science. The known laws of one branch of science have not unfrequently been applied with great ingenuity and success to the practical elucidation of obscure phenomena in other departments. Of this advance the instrument, the name of which is placed above, and the employment of which has recently been introduced into the investigation of diseases of the eye, affords a very good illustration. In drawing attention to it, we do not intend to enter upon a detailed criticism of the various appearances, and the minute shades of difference which the ophthalmoscope reveals, inasmuch as the subject, technically treated, belongs to the domain of pure medicine, and would be neither interesting to, nor be understood by, the general reader. Indeed, it is very possible that many persons have not as yet heard of the ophthalmoscope by name, and very certain that of those who have, many more have but little knowledge of its application. Indeed, so novel is the instrument, and so recondite are its revelations, that we might say, as yet, it has been very partially employed by only one section of the medical profession. Doubtless the time will soon arrive when more will have been learnt by those who now use the instrument, and its employment be more widely distributed.

We propose rather, as briefly as possible consistent with intelligibility, to give such an account of the instrument itself, the principles upon which its action is founded, and the objects which its use is likely to reveal, as may be sufficient to keep the general reader *au courant* with the scientific inventions of the day, even though such inventions may belong exclusively, in the first instance, to one section of the community: we say in the first instance, for, without doubt, in the long run every improvement in the means of diagnosing and rendering clear and indubitable, diseases, in whatever part of our bodies they may be seated, which heretofore have been most obscure and dubious, is of permanent interest to every person. This is especially the case with diseases of the eye, the neglect of which is of such fearful consequence to the sufferer. Now it is precisely this serious class of most obscure changes in the deeper, more delicate, more important, and most hidden recesses of the eyeball, that the ophthalmoscope is destined to light up and reveal with a clearness which will remove most, if not all, of the obscurity which has hitherto concealed them. During the last century no branch of medicine has made greater strides towards attaining scientific precision than has ophthalmic surgery, which has been rescued from the hands of the impudent charlatan and the wandering mountebank, to become in many respects the most advanced branch of practical medicine; yet it must be admitted by everyone, who from attention to the matter is qualified to give an opinion on the subject, that it is in precisely these more important diseases of the eyeball, (in which it is of the utmost consequence to attain an early knowledge of the kind of change which is going on, and the particular structure in which it is taking place,) that hitherto there has been the greatest difficulty in so doing. The outer structures of the eye are within reach and amenable to the examination of everyone; not so the inner. In the earlier stages of disease in these, when examined by the ordinary method, there are often no objective symptoms, while the subjective phenomena are so obscure and confused, as to be not unfrequently of little certainty or value. Hereafter, the ophthalmoscope promises to, nay, certainly will, remove much of the obscurity, and it cannot fail to render the diagnosis of these terrible and insidious changes in the deeper seated tissues of the eye almost as much within the sight of an expert observer as are those in the most superficial parts; and by thus enabling the competent oculist to detect the earliest indications of change (which hitherto has been too frequently beyond his power of observation), it will allow him, by timely treatment, to prevent alterations, which would otherwise, if unobserved, progress until all chance for good being effected has passed away, and hopeless blindness has become the inevitable lot of the unhappy patient. In many of these changes, if far advanced, there is no cure; in them prevention is not only better than cure, but it is emphatically the only cure.

Though it is barely a dozen years since the ophthalmoscope began, in the hands of Brücke and Helmholtz, to assume a form of practical application, the idea of such an apparatus, or rather the principle upon which such a method of examining the eye depends, was first clearly indicated by one of our own countrymen, Mr. Cumming; who, in an admirable paper, published in the 'Medico-chirurgical Transactions for 1846,' clearly pointed out the importance of observing the light which is reflected from the bottom of the eye, and suggested the circumstances under which the interior of the eye itself might be examined. It now appears astonishing that Mr. Cumming's observations, leading not very remotely nor indirectly to the invention of the ophthalmoscope, did not at once excite more attention; but it is perhaps still more wonderful that the mirror-like reflexion from the bottom of the eyes of cats and other animals, which must have been seen by the learned and unlearned, almost ever since the creation, should not have suggested the idea long ago: for in it is the very germ of the subject; light falling upon the concave bottom of the eye of these animals is reflected, and causes the luminous appearance by which the fundus of the eye, in certain positions of it, is seen: only place any other animal, man included, in favourable circumstances, and the same appearance will be observed.

Dilate the pupil, so as to allow the rays of light freely to pass into and out of the eye; let the eye be placed in a suitable position for the rays of light from a luminous body to fall upon it, in a chamber from which all the light is excluded; and let the observer stand in a proper position, which is "as nearly as possible, in a direct line between the source of the light and the eye to be examined . . . . when the luminosity of the interior of the eye will be immediately perceived;" these, as stated by Mr. Cumming, are directions which really comprise the principles upon which the ophthalmoscope must be constructed and used.

Helmholtz's first instrument was a square box, with a darkened interior, containing three parallel plates of glass, placed obliquely at one end, and at the other, one or two bi-convex lenses, to concentrate the rays of light; but the image thus afforded was too faint to be of much value, as most of the light was lost by the intervening plates. A great improvement was shortly afterwards made by the introduction of a concave, or a plane-reflecting mirror, which, though it has been variously modified in shape and mounting, or in the method of being held, constitutes in one form or other the various forms of ophthalmoscope now used; the modifications being rather according to the fancy or the whim of the party using it, than involving any difference in principle. Suggestions have lately been made for a binocular ophthalmoscope, which it is asserted possesses advantages which the single reflector does not, but there is a difficulty in getting a correct focus with it, and the instrument has not obtained general adoption. Leibrich has invented a large and somewhat costly apparatus, with various tubes, rods, and supports for more accurately adjusting the focus, supporting the head of the patient, and fixing the eye under observation: this is said to accomplish its object satisfactorily, but from its being a fixture and cumbersome, is not much used. The instrument almost universally employed, at least in this country, is a circular, slightly concave, mirror about two inches in diameter, having a central aperture of $\frac{1}{6}$ to $\frac{1}{8}$ in. diameter, which, at the pleasure of the observer, may be mounted on a stem, or simply held in the hand, and may be made of speculum metal, of polished steel, or, as is most common, of silvered glass. By this mirror the rays of light are received and reflected upon the patient's eye. The mirror is held close before the observer's eye, with its aperture corresponding with the centre of his own pupil; by this means his own eye is in a great degree protected from the light, while through the aperture he has a full view of the illuminated disk of the patient's eye. The central aperture in the mirror should be of sufficient size to allow of this observation, but no larger, for of course, at this spot, there is no reflection of light: indeed, through this orifice, the bright light, which should all be reflected as nearly as possible, may find admission into the observer's eye, and thus the experiment is interfered with in two ways. With the mirror, is frequently used a double convex lens of about two inches focus, which is held between the mirror and the eye to be observed, for the purpose of concentrating the rays of light before they fall upon the observed cornea. This lens is necessary when the observed eye is flat, or presbyopic; but when the cornea is convex, or myopic, the rays of light will fall upon the retina with sufficient accuracy, without other concentration than the eye itself is capable of affording.

For making the observation, the eye to be operated upon should have had the pupil well dilated by the introduction of atropine; for unless this is done, sufficient light will not enter the eye to be reflected from the fundus and render the illumination clear, nor will the field of vision be sufficient to enable an examination to be made of the whole interior, and disease may likely enough exist, which lying behind the undilated iris must necessarily escape observation. The patient should then be placed in a darkened room, and directed to hold the head as steady as possible with the eyelids widely open, and the eyes looking directly forward fixed as immovably as possible. If a strong illumination is not required, a wax-candle, or if it be necessary, an argand gas-burner, or a camphine lamp, must be placed a little behind, and at the same side of the head as is the eye to be examined, and on the same level as the eyes. The observer then places himself directly before the patient, bringing his eye with the mirror held before it, as nearly as he can in the same plane with the patient's eye, when the rays of light, falling upon the mirror, will be reflected as a diffuse circle of light; this, by adjusting the position of the mirror, may easily be so focussed as to fall directly upon the dilated pupil, when a brilliant illumination of the fundus of the eye will be obtained, and of course any abnormal condition of its various parts may be at once observed. A more interesting and striking picture can scarcely be imagined than a brilliant view of the blood-vessels of the retina and choroid coat of a healthy living eye. Neither do we know of a more beautiful and simple application of optical science, nor of one which is more rich in the advantages which it is likely to confer upon mankind. To those familiar with the more simple of optical laws, the mode in which this image is obtained, will be at once so obvious as to require no explanation; while it would hardly be possible, without the aid of diagrams and a larger space than we can spare, to render it intelligible to those who do not understand them.

We must, however, guard our readers against at once jumping to the conclusion, that because it is now easy for any competent observer to see clearly into the very bottom of the living eye, it is therefore easy to make the observation useful. None but a skilful anatomist and physiologist can do this: inasmuch as he must first not only know of what the marvellously minute tissues of the interior structures of the eye consist, but he must also, by patient and repeated observation, have rendered himself familiar with the appearances which this healthy condition presents under examination with the ophthalmoscope, before he can venture upon the attempt at discriminating between them and those which result from altered and abnormal conditions of the tissues; and after he has arrived at this knowledge he must further learn by frequent examination and careful reasoning, to determine not only in which particular structure the change may be, but the exact nature of the change and the stage of it, whether it indicates an altered condition of a temporary unimportant character, or a morbid state of a more permanent or even irremediable kind; whether the disease be in an early stage, with commencing mischief, or at a period of decline, when any change which is likely to result from it has already been accomplished. He must further know whether any treatment (and if any, of what nature) is likely to be beneficial; or whether the change involves such organic alteration in the structure of the part, that no remedies can benefit: even further information may be obtained if this latter condition be established, for we learn whether the disease be such as may be limited to the eye or may extend to the whole system, ultimately destroying not only the organ itself, but the life of the patient. It is upon the answers given to these, and similar important questions, that the knowledge revealed by the ophthalmoscope is destined to be of the utmost value. We say advisedly "destined to be," for though fully prepared to recognize the great steps in advance, which the diligence of comparatively few observers has secured, and to acknowledge that many of the more clearly marked diseases are already readily diagnosed, it must be confessed that much still remains to be done; there is still much to be learnt, and something to be unlearnt. For ardent minds will dogmatize on insufficient data, and inexperience is apt to overlook difficulties which stand in the way of those who know more; while ignorance will not unfrequently hazard a rash assertion rather than confess to a want of experience in the use of an instrument with which a patient, having heard something wonderful about it, expects, as a matter of course, that the party he consults should be perfectly familiar. We could cite examples of strange assertions and crude speculations which have been made after gravely peeping through an ophthalmoscope. This, however, is no valid argument against the value of the discovery itself. The difficulty of acquiring any technical knowledge, sufficiently precise to be valuable, is often great; far more so than many people suppose. No greater advance in the means of detecting and distinguishing diseases of the chest has ever been made than through the invention of the stethoscope. Now what this simple instrument is to the chest, the ophthalmoscope is and will be to the eye. It has required nearly fifty years of diligent observation, and the labour of thousands of learned men over almost the whole world, to define the revelations of the stethoscope as now understood by the initiated, and still there are multitudes who make a show of using it, but do not understand its teachings. So it is, and probably long will be, with the ophthalmoscope.

Appearances which are not now understood, will ere long have their true significance shown to those who will take the trouble to learn; and errors which are now committed will be avoided, while accumulated experience will clearly indicate the value of that which is now obscure. It is not unlikely that improved forms of instruments may be suggested, by which even more perfect views than can now be got of the fundus of the eye may be obtained; and instruction in their use will become so common, that it will be regarded as a necessary part of the duty of those who undertake the especial treatment of diseases of the eye, to obtain as familiar an acquaintance with the use of the ophthalmoscope as they are now obliged to have with the instruments used in the performance of physical operations, or as the physician to the hospital for diseases of the chest must have with the stethescope. Already a suggestion has been made by a Canadian to add to the ophthalmoscope an apparatus by which photographs of the bottom of the eye may be obtained: this, though not at present of practical avail, may not unlikely become so ere long.

When it is considered how short a time has elapsed since the power of seeing into the bottom of the living eye was demonstrated to be practical, it is satisfactory to know how much has already been accomplished in rendering the knowledge useful in the treatment of diseases there seated.

It is not intended to be asserted that it will ever become very easy to determine by the ophthalmoscope the value of all the changes which take place in the living eye, any more than it is to become a learned astronomer, or to acquire any other knowledge which involves the possession of intellect, and the expenditure of labour; but to those who possess the one, and will undergo the other, the ophthalmoscope is, and will be, of the greatest value. Medicine is daily becoming more of a science, and those who care to keep pace with its progress will have to do so by the study and adoption of those means of which the stethescope and ophthalmoscope are illustrations.

ACCLIMATIZATION.

By Dr. C. COLLINGWOOD, M.A., M.B. Oxon., F.L.S.

WE recollect hearing a distinguished English Zoologist not long since assert that, notwithstanding all the Societies devoted to this object, and all the assiduous care which had been bestowed upon the deportation and breeding of animals, with a view to adapt them to their new homes, no successful instance of acclimatization could be produced by the supporters of the system. But either the veteran systematist must have made a false estimate of the true nature and objects of acclimatization, or he must have judged of the facts by too narrow and procrustean a rule; for no one who is acquainted with the efforts and the proceedings of the two great Acclimatization Societies, those of Paris and Victoria, can believe that the sums expended, the energy evinced, and the interest aroused by them, can be for a mere visionary and shadowy object. The reports which are issued by these Societies from time to time display an amount of successful enterprise, which is a subject of just congratulation, and we cannot but wish prosperity to aims which are at once useful and philanthropic, and which, in some cases, are redeemed by a touch of romance from the ordinary utilitarian ends of similar undertakings.

Among the useful animals to which the Société d'Acclimatation* have directed special attention, the yak is conspicuous, a native of Thibet,—a creature possessing a most valuable skin or fleece, and which is found to breed very readily in the garden of the Society; and, although it at present yields but little milk, it is hoped that in time, the influence of domestication may render it more valuable in this as in other particulars. Several prizes are offered for the breeding of these animals, *viz.* :—two prizes of 2.500 francs each, for anyone who shall produce by the 1st December, 1865, four yaks of pure blood, of a year old, and of his own breeding; also other prizes of 1,800 and 1,200 francs, for crosses between yaks of pure breed and mountain cattle (vaches de travail); as well as smaller prizes for such animals as shall prove apt as beasts of labour or of burden.

Similar experiments are in course of trial upon Angora and Egyptian goats, Caramanian and Merino sheep, &c., which are reported to be in a fair way to success; and encouragement is held out by prizes of various amounts, for the production of small flocks of these animals, for the purest breed, and the heaviest producible fleece.

The gathering together in good condition, and in sufficient numbers to establish a species, of foreign animals and plants is necessarily a very slow and delicate process, and much time must obviously be expended before very decided results can be expected. Most of these animals breed only once a year, and their natural increase is, therefore, slow, however eminently they may prove themselves adapted to their new home. Nor is it to be expected that every experiment of the kind should be at once successful. We should regret to see an energetic movement damped by temporary misfortune, and we trust that the ill success attending the first attempts (in 1860) at the introduction of Llamas and Alpacas into France will only be a difficult stepping-stone to the accomplishment of a task of great importance, both in an agricultural and economical point of view.

A second attempt is already contemplated, and the Presidents of Peru and Equador have offered two troops of these animals, and M. St. Hilaire has published a paper relating the causes of the recent failure, with instructions as to their treatment with a view to avoid such failure in future.

Similar attempts are being made to utilize the wild ass, and

* The Imperial Zoological Society of Acclimatization publishes a monthly 'Bulletin,' the numbers of which are now before us, and contain a great deal of most interesting matter ('Bulletin Mensuel de la Société Imperiale Zoologique d'Acclimatation.' Paris: Masson & Fils). The object of this Society (which has been founded ten years) is to co-operate "for the purpose of introducing, acclimatizing, and domesticating species of animals which are either useful or ornamental, and the improvement and multiplication of races newly introduced or domesticated. The Society also occupies itself with the introduction and cultivation of useful vegetables." M. Drouyn de Lhuys, the Foreign Minister, is President of the Society, and its council includes the names of Passy, Richard, Dupin, Cloquet, Dumeril, Quatrefages, and others; while it also enjoys a peculiar share of the Imperial countenance and patronage.

Burchell's zebra, quagga, &c., and prizes for the successful breeding of these animals in a state of captivity or domestication are offered, as well as for crosses between them and the mare and the ass.

Among birds, the ostrich has been introduced and domesticated in Algeria and in the south of Europe, and prizes of 1,500 francs are offered for the possession of flocks of these birds, bred by the owner. Attempts also are being made with the cassowary of New Holland, and the American rhea, the crowned pigeon, the ocellated turkey (Meleagris ocellata), Californian quail, &c.

We have not alluded to a Society which exists in London of a similar character, not because it is unimportant, but rather because we wished to call attention to the extensive scale upon which the Societies of Paris and Melbourne are engaged. The most important work of the London Acclimatization Society is in the matter of Pisciculture. Of this Society Mr. Frank Buckland is an active member, and his exertions in the cause of fish-hatching, and the preservation, rearing, and introduction of valuable fish in the rivers of this country, must be appreciated by everyone. The recent discovery of a fine salmon, which had revisited the Thames, makes us hope that the labours of the pisciculturists will be aided, as far as the metropolis is concerned, by the great works which have been undertaken for the purpose of purifying the river, and we trust that attention is now sufficiently aroused to the necessity of protecting a single fish like the salmon, to prevent that extirpation of it which a short time since seemed but too probable. Nor should we altogether omit to allude to the success which has attended the efforts to cultivate oysters.

The French Society have also largely devoted themselves to these subjects, and we regret that our space will not permit us to enter more fully upon these labours. Several valuable papers upon Pisciculture appear in the first series of 'Bulletins,' with the names of Vallenciennes, Gillet de Grandmont, René-Caillaud, Lamiral, &c., attached.

The cultivation of the silkworm has also attracted much notice, and in this department the name of M. Guérin-Méneville stands conspicuous. Several species have been introduced into France, and largely supplied with the trees which are their natural food. Among these are the Bombyx Cynthia, or Ailanthe silkworm, and more recently the Ya-ma-mai, or oak silkworm of Japan. The latter have been introduced at some risk by M. Pompe van Meerdervoort, Director of the Medical School at Nagasaki, who procured a number of eggs, the exportation of which is strictly prohibited by the Japanese, which have been reared in France successfully; and it is believed that this important insect, which lives upon the leaves of the common oak, will support the variations of our climate without much difficulty. The Chinese oak silkworm (Bombyx Pernyi) has been imported also, but the experiment of rearing it has for the present failed.

The popularity of the subject of acclimatization is well illustrated by the prominence lately given in our leading journal, to a report about to be issued by the Acclimatization Society of Victoria; and it is their experience that paragraphs referring to the proceedings of the Society attain a circulation more general than almost any other subject in English and foreign newspapers. And although the Society to which we are now referring is the one best known, and whose results have been most tangible, as their efforts have been most unwearied, it may be mentioned that amongst its fruits, perhaps, may be reckoned numerous other such Societies which have taken that of Victoria as their model; so that they now exist in almost every colony in those seas, as at Sydney, Hobart Town, Adelaide, Brisbane, Auckland, Lyttleton, and Dunedin. The French Society, too, have established most cordial relations with that of Melbourne, and a French man-of-war is at the present time engaged in transporting thither specimens of the yak, the ostrich, and other animals. Moreover, the British Government has recently been induced to take up the project with an amount of consideration altogether without precedent, the foreign and colonial offices having recently sent to British emissaries in all countries in the world, a series of questions as to the various desirable natural products of each country: and the Admiralty has issued a circular to all commanders of Her Majesty's ships, directing them to render every service in their power to the cause of acclimatization, in the conveyance of specimens.

The inauguration of the Acclimatization Society of Melbourne on its present footing is comparatively recent, since less than three years have elapsed since it was amalgamated with, and undertook the duties of the Zoological Committee. Its Council is composed of gentlemen engaged in commerce, who willingly devote much valuable time to the subject, under the Presidency of Mr. Edward Wilson, the founder of the Society, and to whom has just been awarded the great Gold Medal of the Paris Society, which was instituted in 1862 for the traveller who, during nine years, had rendered the greatest services to the cause of acclimatization. Since the amalgamation, in consequence of the increasing number of animals and the unhealthiness of the original site of the gardens, an entirely new establishment has had to be formed in the Royal Park, involving a very heavy expenditure in fencing, planting, forming excavations for ponds, building a house for the superintendent, shelter-sheds, pens, &c., and the Society now ask for a subsidy from the colonial government. Among other items laid upon the table of the Assembly, 3rd February last, was one of 4,000*l.* for the Acclimatization Society, coupled with a condition that 650*l.* should be raised by private subscription. It is to justify this vote that the Society has published the results of its efforts, in order to prove to the Government that the public money is being legitimately spent, as well as to create a wider interest in the object of the enterprise.

The herd of Camels brought from India, at an expense of 120*l.* per head, had become scattered, and were in a fair way of being annihilated under the various exploratory expeditions. Such of them as could be saved have been collected at Mr. Wilson's station, at the Wimmera, where they are now breeding regularly, and forming the nucleus of probably a large herd, available at some future day, either for exploration or for conveying the products of remote stations to the more arid districts.

Reports have reached us of the failure of the first attempts to naturalize the Peruvian Alpaca, and out of 300 introduced, five years since, from Peru, and purchased by the New South Wales Government for 15,000*l.*, all have died, and their progeny, 330 in number, are in an unhealthy condition—so much so that in the colonial legislature it was determined to get rid of the cost of keeping them, and disposing of them at once, by auction or otherwise. But on the other hand the official report of the Society prepared in the present year shows that another attempt is likely to have a more successful issue. It is there stated that the little flock of llamas and hybrids imported from England, and under the care of Mr. Duffield, have been diligently cared for. They have been crossed with pure alpacas, and young ones of the second cross are now being dropped. Since landing, their numbers have increased from 19 to 56. Thus, while the Camels suffered from being too greatly scattered, the Alpacas failed from too great concentration.

The Angora goat has been received from the Paris Society, and is rapidly multiplying; they are being crossed with the common goat in considerable numbers. The Cashmere goat also has been imported by an enterprising gentleman at Maryborough, who is now experimenting with it. Various breeds of sheep, some of which show signs of a peculiar adaptability to a hot climate, are also under experiment. The fallow deer, the Indian elk, and the axis have been successfully imported, bred from, and turned loose at Wilson's promontory and other places. Numerous specimens of the hog-deer of India, and other species from Manilla and Formosa, are also in the Society's possession for similar purposes.

With regard to game, the hare has been sent by the Zoological Society of London, and has been turned out on Philip Island, where it is breeding freely. Various breeds of pheasants, partridge, grouse, and quail have been introduced, and some liberated. The English wild duck has multiplied very freely. The Egyptian goose has bred, and promises to be thoroughly acclimatized. So also the wild peafowl of Ceylon has thriven and bred, while the white swan and various kinds of foreign doves and pigeons have been introduced and liberated in various localities.

Among fish, the salmon has been the object of considerable pains and expense on the part of the Tasmanian legislature, and promises well. The gouramie, represented as the best fresh-water pond-fish in the world, has, after many trials, been introduced; and carp, tench, roach, dace, and gold fish have been distributed in various localities favourable to their multiplication. Grey mullet and the edible crab have also been introduced, not, indeed, in sufficient numbers to justify a hope of establishing the breed, but amply suggestive of what will be done in the future.

The Ligurian bee, from its industrious and wonderfully prolific qualities perhaps the most valuable insect in the world, is multiplying with almost incredible rapidity, and will soon be accessible to all classes.

One of the most interesting features of this Society's work is the estimate by which value is determined. They do not limit their inquiries to objects of immediate or material usefulness. They do not ask simply, whether certain animals are good eating, or otherwise adapted for daily use, but they consider that the eye and the ear should be gratified also, and that everything is worth securing which adds cheerfulness to scenery, and revives home associations on colonial ground. The introduction of insect-destroying birds is, it is true, an object arrived at; but with this has been combined an effort to surround colonial residences with such reminders of the old country, as thrushes, blackbirds, skylarks, starlings, chaffinches, and sparrows.* The goldfinch, greenfinch, linnet, yellow-hammer, ortolan, bunting, robin, and canary, and many kinds of the smaller birds of other countries, as the Chinese sparrow, Java sparrow, and the Indian mino, are being accumulated in the aviaries of the Society, and many of them have already bred there. The nightingale and the hedge-sparrow have been promised them by ladies at home, and the Queen herself has made an effort to supply them with the rook. Such news may be surprising to the farmers of this country, who mercilessly destroy the very birds which our wiser antipodean brethren are seeking to introduce: but such is the fact, and we believe the Australians are right.

In concluding this brief survey of a subject of so great and increasing interest, we ought to do full justice to the aims of the Australian Society, who regard the advantages of acclimatization in a light which raises it above a mere utilitarian and commercial speculation. Deprecating the sneers and misrepresentations of thoughtless and ignorant persons, who have no conception of the varied objects and considerable interests which it embraces, they openly state their object in stocking their country with new, useful, and beautiful things to be, not only to add to the national wealth—not only to suggest new forms for colonial industry, but, also to provide for manly sports, which will lead the Australian youth to seek their recreation on the river's bank and mountain side, rather than in the café and casino. Nor do they stop at this praiseworthy avowal; we have alluded to a touch of romance in their undertaking, and it is not everyone who, endowed with a commercial mind and deeply engaged in the practical business of life, will fully enter into the desire the colonists express, not only to add new elements to the food of an entire people, but also to surround every homestead, and the path of every wayfarer, with new forms of interest and beauty. This is their unwonted aim, and we cannot but rejoice that such a truly poetical feeling should mingle with the sterner and more practical realities of the system. Such a body may well claim the sympathies of every good man, on the ground that they are engaged in a noble work, and we most cordially wish them God speed in their useful and humanizing undertaking.

* In 1830 a merchant wishing to import sparrows to the Havanna, found on arrival that the customs duties were so heavy that he could not hope to sell the birds profitably; he therefore let them fly—the birds entered the island free of duty, and at the end of some years their number was so much increased, that in certain localities they are as numerous as they are at home. (Graells, delegate of the Acclimatization Society at Madrid.) This fact is an encouragement to the Australian movement.

COPPER MINING IN TUSCANY.

Account of the Copper Vein occurring in Tertiary Volcanic Rock worked at the Mine of Monte Catini in Tuscany.

By Professor D. T. ANSTED, F.R.S.

THE copper mining of Tuscany has within the last quarter of a century assumed considerable importance, and more than one of the great mining successes of the time has been gained there. The position and circumstances of the mineral veins that yield these supplies are peculiar, and differ much from the cases with which miners are familiar, not only in England but in Europe generally. At the present time, when everything within the range of the Italian Government is accessible to our countrymen, it is well that a knowledge of these sources of mineral wealth and great scientific interest should be widely known. I make no apology, therefore, for offering a few notes on the subject, collected during a visit I paid to Tuscany last autumn.

The river Cécina is one of the largest of several small streams that take their origin in the tertiary hills west of the valleys of the Arno and the Tiber. These streams, after crossing a few miles of tertiary rock, through which here and there picturesque hills seem to rise up without any reference to the surrounding country, enter the Mediterranean in the flat alluvial tract extending almost uninterruptedly from Leghorn to Cività Vecchia. They traverse a country, parts of it covered with vegetation at certain seasons, but many parts almost startling from their extreme bareness and desolation. In these places, and indeed everywhere in this part of Italy, the effect of the last heavy rains is always traceable on the loose sands of the valley and plain, and at intervals we find fissures from which issue hot, sulphurous vapours. Formerly there were numerous small lakes or lagoons of muddy water boiling vehemently. The low plains were redolent of the disagreeable odour of rotten eggs, owing to the emanations of sulphuretted hydrogen gas, and carbonic acid gas issued in great quantities from certain crevices. The soil was loose and dangerous, and sheep, cattle, and pigs, and even human beings were frequently buried in the treacherous and shaking soil. Within the last thirty years the country is much improved. The vapours have been utilized in a double sense, for vast quantities of borax are now economically manufactured by taking advantage of the natural heat of the streams and springs to evaporate the solutions of valuable salts that abound in the district.

The axis of the fissures that yield both borax and the hot vapours is parallel to that of the Apennines, and also to that of a number of eruptions of serpentinous rock in Tuscany. It agrees, further, with the direction of several recent earthquakes in Italy. Fissures in the serpentine rock itself, and also in the rock immediately adjacent, contain numerous minerals, and among them some ores of copper of very great importance. One of the veins is worked in the mine of Monte Catini to great profit, and under very interesting conditions. Others are worked in the Val Castrucci, in the Maremme, near the coast, and in this latter case there is evidence that the ancient Etruscan inhabitants of Italy were able to take advantage of the minerals there found. In the Massa Maritima, the veins traverse the tertiary rock of the district. They range from N. W. to S. E. The veinstone or earthy mineral accompanying the ore is usually quartz. The veins are wide, the principal one measuring from 30 to 50 feet. The terrible miasma of the 'Maremme,' as the marsh lands of this part of Tuscany are called, is a serious drawback to working the mines of this district.

Besides the open fissures containing ore, found in the sedimentary rocks themselves, there are dykes, filled with volcanic rock of the nature of basalt, traversing the same rocks, and in some of these copper has been worked from time immemorial. The greater hardness of these dykes compared with that of the sedimentary rock, has helped to preserve the latter from the action of the weather, and thus to leave hills of which the dykes in question are a nucleus. Although but a short distance from the coast, where a few hours' exposure to the evening air is sufficient to induce a fatal attack of malaria fever, the villages on the hills are quite healthy, and near Campiglia, one of these villages, is a fine old Etruscan mine from which copper ore has been taken on a scale worthy of the old Etruscan population whose works of more than one kind have endured longer than history can record. At present the ore is poor though abundant, but doubtless in ancient times there must have been good reasons for the construction of excavations that more resemble huge natural caverns than ordinary mining work. That these excavations were only made when something was to be gained by them is evident from the extremely small proportion of the levels or mere galleries of communication. The rock is very hard, and the labour required must have been prodigious.

The rock in which the copper ore is found in this mine is partly the ancient lava, but partly also the rock penetrated and altered by it. Thus, occasionally, there is a marble floor to the vein, and the limestone intersected by the original fissure seems to have been converted into this marble by the irruption of the heated matter to which the dyke owes its origin.

The very important mine of Monte Catini is another curious instance of the same kind. It is situated in an altered lava close to a boss of trachytic rock a few miles west of Volterra, and some distance north of the Massa Maritima. The distances indeed between the points hitherto described is somewhat considerable, though all are intimately connected by geological links. Thus Campiglia is 15 miles west of Massa, and Monte Catini about 25 miles to the north of both. The coast railway from Leghorn, open at present to Follonica on the way to Cività Vecchia, has, however, rendered all these places much easier of access than they formerly were. There is a branch of the main-line running up the Cécina towards Volterra for the benefit of the borax works and the Monte Catini mine. Close to Campiglia is a much larger mass of trachytic rock than that near Monte Catini, but no doubt answering the same purpose. Both at Campiglia and Monte Catini, the injected or erupted rock has brought up some of the secondary rock, but the actual date of the fissure and its filling up must be comparatively modern in both cases. All these Italian mines differ in a striking and even startling manner from those of Cornwall and other parts of the British Isles. They are quite as different from the copper mines of Germany and Scandinavia. They introduce us to the phenomenon of a great accumulation of copper ores of the ordinary kind (copper pyrites), in veins in comparatively modern volcanic rock, these veins having been formed long after the older tertiary rock had become deposited and hardened. The cretaceous rock, and even the older tertiaries had been in some cases elevated before the formation of the fissures now filled up with lava, and the lava had cooled and solidified and cracked before the copper made its appearance.

The mine of Monte Catini (della cava) is worked in a very peculiar vein of soft magnesian rock (approaching serpentine in its nature, but much softer), occupying a dyke or fissure in the *gabbro*, which is apparently itself an eruptive rock originally forced through, over, and amongst the upper cretaceous limestone of Tuscany, here called *alberese.** The alberese is a compact pale blue, or greyish blue limestone, hard and penetrated with numerous strings of calc spar. It occupies the hills and neighbouring high ground, but is generally covered with a soft marly rock, often containing gypsum, and sometimes rock salt. The latter mineral is abundant, and is worked in the Saline in the valley of the Cécina adjacent.

The alberese is a cretaceous limestone, and the overlying soft marl are tertiary. It appears to me that there has been an eruption of igneous rock through fissures in the alberese at a time when the tertiary deposit was much more extensive than it now is. Thrust up through this rock, which is locally squeezed, contorted, and broken, and forming a dyke in the soft tertiary clays above, the nearest adjacent clays are converted into shales, which are hard and compact enough where they approach the igneous rock. In certain places the flow of lava has been through two nearly adjacent fissures, meeting one another, and leaving at and near the place of contact large open spaces. In the course of time the softer earth on each side of the vein has been washed away, and there is now left on the flank of the mountain little more than the hardened and altered rock. This forms the nucleus of *gabbro*, which here consists of irregular rounded lumps of hard, compact rock, resembling greenstone embedded in a kind of soft porphyritic mass, weathering rapidly on exposure, and easily removed underground. This gabbro looks much like a true serpentine (pale greenish crystals in a dark green bed), and is evidently highly magnesian.

It is in fissures closed towards the surface, and there presenting nothing but reddish clays, which, however, are easily distinguished from the gabbro, that we find the only indications of the rich lodes, or rather pockets, existing below. It is believed that in former times

* The name *alberese* is given both to the chalky limestones of the upper part of the cretaceous series, and also to the similar rocks of the upper part of the eocene tertiaries. It expresses mineral character. At Monte Catini the *alberese* of the cretaceous period is thrust through the *alberese* of the tertiary period, and they are in contact.

much valuable ore was got from the surface in other portions of the lode, or from pockets intersected at the surface, but of this there now seems no indication. Generally, the narrow cracks with their red clay contain a few small rounded nodules of rich sulphide of copper, often with very little iron. It is these that yield the larger lumps when followed downwards.

The vein, as recognized at present, is very irregular in width and contents. The chief ore has been obtained in isolated pockets at various depths, down to about 120 yards. These are, to all appearance, absolutely irregular. They do not seem to have reference to any peculiar condition of the serpentinous veinstone beyond the presence of red clay. They are not confined to any part of the lode, but range out of it into the gabbro, some of the richest deposits now worked being altogether in the gabbro. Veins pass off, commencing with a thin line of orey serpentine, and running out of the main lode into the gabbro, but gradually enlarging and becoming very rich. The general direction of the lode is east and west, and the dip south, and the richest of these side veins have similar bearings, but dip at a greater angle.

At a depth of about 80 yards the lode is interrupted by a broken mass or dome of alberese and shale, near the contact with which a large quantity of excellent ore was found. Below this again gabbro has been reached. In the main adit, driven for more than a mile to drain the mine to the 30-fathom level, a somewhat similar mass of alberese and shale was crossed. It would seem, therefore, that the fracture of the rock through which the lava was poured occurred at about this point, and thus irregular fragments of rock of considerable size are apparently included. But I noticed that the limestone is only so far altered at this point as to show more than usual of that peculiar interlacing of calc spar, for which it is elsewhere more or less remarkable. The general character and appearance of the rock (a compact pale grey indurated limestone) is accurately preserved close to the gabbro.

Not only is the limestone not altered, but the shales with it are still soft, and even rotten. The serpentinous mass containing the ore is also in the same state. It is only by the extreme crushing and squeezing that the limestone and associated shales have undergone, and by observing that they are bent, and broken, and turned in every direction, that one can realize the fact of the great forces to which they have been subjected.

In all parts of the gabbro and in the serpentinous and steatitic masses of the vein, calc spar, crystallized more or less perfectly, is to be seen. But magnesia is the prevalent mineral. All the rock is more or less steatitic, and presents those peculiar appearances that steatitic minerals so often do. A strong resemblance to slickensides is one of these, and most observers have concluded, from the numerous striæ and polished surfaces which the stone presents, that the whole vein and its contents have been slid over one another, and that the striæ and polished surface are mechanical. This I am inclined to doubt.

The ore in the serpentinous vein is all in nodules. These vary in size exceedingly, but they vary little in appearance, and all probably have the same origin. They are masses of sulphide of copper and iron, the central part being the hardest and most ferruginous, and the other part containing the richest and purest copper ore. This outer part is often peacock ore, and sometimes grey sulphuret. Earthy carbonate of copper is rare, and malachite, or compact carbonate, quite unknown. Native copper is found, but only in small detached fragments (not crystalline) in the gabbro. No crystals of copper ore have been found—a fact sufficiently remarkable.

The kidney-shaped, rounded nodules of ore are in some parts of the lode accompanied by a considerable quantity of equally rich ore, disseminated through the veinstone, and only separable by dressing. It has sometimes been thought that these rounded masses are water-worn, but this I greatly doubt.

One of the first things that struck me when I visited the Monte Catini mine, and looked at the surrounding country, was the contrast it offered to ordinary mining districts in our own country, and the curious resemblance to what I had seen in Algeria, in the mines of Mouzäia, in the Lesser Atlas. Here rich ores of similar nature have been found distributed in the same irregular manner in bunches communicating by narrow threads. The veins range N.E. and S.W., parallel to the mountain chains, and traverse altered tertiary rock, cretaceous limestone, and shale. The serpentine is there absent, though there are not wanting trachytic porphyries, representing those of Monte Catini. The fact that tertiary rocks are fractured to form veins in both cases, and the mode in which the veins have since been filled up, are not the only points of resemblance.

Another remarkable instance occurs in the celebrated mines of Cobre, in Cuba, where rich and abundant copper ores are found in a district abounding with limestone. The rock containing the vein here consists, however, of a calcareous porphyry, passing into limestone on the one hand, and basalt on the other. The particulars of this curious lode I have described in the 'Proceedings of the Geological Society,' vol. xiii. (1857), p. 240. The general bearing of the lode is east and west, parallel to the coast, and to the principal mountain ridges.

To those accustomed to regard the great system of veins, the principal deposit of ore, and all the important modifications and transformations of rocks and their contents, as events altogether beyond recent geological times, these accounts of very important deposits of copper in modern calcareous rock and lavas of tertiary date, cannot fail to excite astonishment. In many respects the vein of Monte Catini is exceptional, but it is extremely suggestive, for it presents to us an example of recent metamorphic action of the most energetic kind connected with modern volcanic disturbance, so far as upheaval and fracture are concerned, but also indicating the presence and influence of water, by whose agency crevices, once formed by violence, have been subsequently filled up. The steady, permanent, and all-pervading influence of water, producing now the same effects that it has always done, is perhaps nowhere more clearly exemplified than in Central

Italy, where a complicated series of lavas, of various dates, penetrating cretaceous and tertiary rocks, is in turn penetrated by hot vapours and currents of water. These in one place have left behind deposits of copper ore, in another pure sulphur, in another *lagoni* or pools, saturated with salts of borax, while carbonic acid gas, nitrogen, and sulphuretted hydrogen gases issue in abundance.

It is by the help of these gas and water currents, and in the natural course of operations that belong to the ordinary conditions of things, that the mineral veins of Monte Catini and the other mining districts of Tuscany have been filled, and this it is which gives the subject a special interest and value.

CHRONICLES OF SCIENCE.

I. AGRICULTURE.

The second quarter of 1864 commenced in the agricultural world amidst important sales of home-bred short-horn herds of cattle, and it closes in the midst of important agricultural meetings. These are matters rather of commercial than of scientific interest, and yet they have aspects interesting to the man of science. The enormous prices realized for certain families or strains of blood among pure bred live stock possess an interest apart from that which they present to the crowd of enterprising men who are following in the steps of Lord Spencer, or Lord Ducie, Thomas Bates, Jonas Webb, Colonel Towneley. These who have realized hundreds of pounds for individual bulls and cows—the last, who obtained last March upwards of 7,000*l*. for a herd of 56 animals of all ages—have not only illustrated the enterprise and wealth of English agriculturists, a matter only of commercial importance, but they have proved the power of the breeder to create that fixity of type in his animals, out of which this extraordinary value has arisen ; and this is a matter of scientific interest.

It may be illustrated by the history of what is called the "Duchess" tribe of short-horns. More than fifty years ago, when Charles Colling's herd was sold, a young heifer named Duchess was bought by Mr. Thomas Bates, of Kirkleavington. From her was descended this tribe, which are believed to possess all the leading merits of the breed in an extraordinary degree. In particular they are possessed of a remarkably soft and silken touch—abundant hair, and other indications of vigour—most symmetrical form, great and equal width of back, well-arched ribs, and prominence and width of bosom. They possess, in fact, great precocity of growth, and a tendency to grow most and fastest in those parts where the flesh is of the best quality for food. They have the highest reputation also for the certainty with which their bulls hand down these properties to their offspring ; and they thus command the very highest prices in the market. This is one of the results of what is called "breeding in and in." Animals that have inherited again and again, in the course of their pedigree, the qualities which relationship in blood has conferred in common, possess those qualities much more energetically than others do in whom they are observed for the first time. A cross-bred ram may have a very desirable coat upon his back, and a very well made carcase of mutton within that coat ; but it is exactly a toss-up whether his progeny acquire the character of his sire or of his dam. If sire and dam for generations back, however, have exhibited constancy and uniformity of character, then that character is certain to reappear in their offspring, which, in his or her turn, will possess still greater power of transmitting good tendencies to the succeeding generation. It is thus that not only in the "Duchess" blood, but in other tribes descended from the Kirkleavington herd, we have as the result of Mr. Bates's resolution, patience, skill, and constancy, qualities which reappear in generation after generation of Kirkleavington families of the short-horn breed, until the animal may now be safely characterized as good if known to be of Bates's blood. Bates's blood, or rather Bates's *brains*—for it is the mental, and in many important particulars, the moral character of the breeder which is reflected now in so many different herds—is merely another word for patient persistence in breeding from animals of a given type, in a great measure disregarding the question of relationship, if they possess the requisite health and vigour of constitution. Of course, when evils of any kind are inherited, such as a tendency to disease or weakness of any kind, breeding in and in will intensify and hand that down with as much certainty as any other quality; but the natural law of breeding which obtains amongst gregarious animals, where the strongest sire is the father of the herd or flock—to the almost entire disregard of previous natural relationship, is a safe one to follow. It is a natural law of this kind that gives to particular herds and flocks, where they have been long under the control of one man, their uniformity of character from year to year. And it is out of the consequent certainty which animals thus bred transmit the qualities they have inherited, that those extraordinary prices are commanded by them, which, while they sometimes startle the commercial world, have thus an interest for the man of science.

The other topic of the period, of chief agricultural interest, is the annual meetings of our great national and provincial Agricultural Societies. On these occasions, the best animals of all our breeds of the domestic animals of the farm, and the best machines known to agriculturists or agricultural engineers, are collected, professedly for the prizes offered by the Society, really for the purpose of that advertisement, publicity, and distinction, which mere exhibition before a multitude, and especially the achievement of any award of merit, under such circumstances confers.

Our national societies with incomes of 10,000*l.* per annum, and the many local and county societies with incomes of one to three thousand pounds each, are among the most striking illustrations we can quote of our agricultural energy and enterprise; for these sums are but a fraction of the expenditure which these annual shows occasion, and give but a faint idea of the commercial advantages which they offer; and the strictly educational results of these meetings in which we are here more particularly interested, can hardly be overrated. Breeders realize their own deficiencies by a comparison with the best animals of the best herds and flocks; and machine makers have both their inventive faculties stimulated and their manufacturing abilities quickened and increased by competition with each other, on the same field close to one another, where the prize of commercial merit is so great. Above all, the agriculturists of a whole province realize the progress which the best examples thus collected for their inspection prove to have been accomplished.

If we except the journals of our agricultural societies by which agricultural progress is brought directly under the notice of readers, these annual shows are the only educational influence which these societies exert. It has only lately been brought under the notice of the Royal Agricultural Society of England that one of the objects for which, according to its charter, it was incorporated, is the promotion of the better education of those who live by the cultivation of the land; and that except indirectly, as by journals and exhibitions, nothing whatever has yet been done by it in discharge of its duty in the matter. A committee of inquiry into the subject is now sitting, which will, we hope, result in some more definite and systematic attempt than has yet been made to bring the great influence and large income of the National Society to bear upon this subject. What seems to be wanted, and what is within the competency and indeed the duty of the Society to effect, is not any such stimulus of general middle class education as our Universities and the Society of Arts are presenting by their annual examinations of students, nor any such guidance and assistance as the Government offers by its Inspectors and endowments of schools; but help, both in guidance and in stimulant, to *professional* agricultural schools, and the establishment of these in greater number than they now exist. The Royal Agricultural College at Cirencester is indeed, we think, the only one of the kind in Great Britain. It is, as we believe, owing to a culpable neglect of the seventh object specified in the Charter of the Royal Agricultural Society of England, as among the purposes of its incorporation, that that institution is not in a more flourishing condition than it now presents, and also that many of similar character have not been established in our principal agricultural counties.

There is an able review of recent agricultural progress drawn up by Mr. Thompson, M.P., in the current number of the 'Journal of the Agricultural Society.' It proves that the importation of guano and of bones, the manure manufacture, the more general application of steam-power in agriculture, and the influence of the National Agricultural Society, have together added greatly to the fertility of English soil. There is, however, a singular exception to this increased produce, which needs to be more urgently pointed out to agriculturists than it has yet been. The quantity of mutton sent to market appears to be hardly more now than fifteen or twenty years ago. The number of sheep and carcases sent to the London market does not appear to have materially increased during that time. With wool at the extraordinary price which it has of late commanded—2*s.* to 2*s.* 6*d.* per lb.—mutton at a price unknown ten or fifteen years ago, and a climate which over most of the island has all along impressed observers with the idea that succulent and grass growth, sheep food in fact, is a much more natural produce of our soil than seeds and grain and ripened produce, it seems impossible to doubt that our flocks and herds must multiply, and our farm management be more immediately directed to this end than it has been.

It does not necessarily follow from this that our grain produce would be diminished. The increased manure derived from the consumption of increased cattle food tends to the increased fertility of our arable lands, and in this way corrects the effect which would follow the apportionment of more acres to the growth of grass and green crops; and it is quite possible largely to increase the growth of green food without diminishing our extent of green crops. Nowhere does liberal management more certainly produce a greater growth than in the case of grass.

Italian rye grass in particular seems to yield a crop which is limited only by the quantity of manure applied, and it is through this crop, doubtless, that the sewage of our towns will yet yield to that "cleanly manipulation," which is to convert it into milk. This subject is again brought under public notice by the appointment of a Committee of the House Commons, to inquire into the engineering difficulties in its way. What the result will be when these are overcome, and the liquid refuse of our towns is spread over fields of grass at some distance from the population, is plain from the instances of Edinburgh, Rugby, and Croydon. Near the latter town we walked the other day over Mr. Marriage's farm of 300 acres, almost wholly under sewage and Italian rye grass, where 30 to 40 tons of grass per acre are mown annually, and sold at 12*s.* to 15*s.* a ton on the ground, and 20*s.* to 23*s.* a ton in London.

On these particular departments of the agricultural field, and especially on the great question of the national food supply, in which they all unite and culminate, there is great lack of trustworthy information, and it must be stated with satisfaction, as strictly within the scope of a scientific record, that an additional attempt has just been made by Mr. Caird, M.P., to urge on Government the duty of collecting the agricultural statistics of the country.

"The need of authoritative (because accurate) published intelligence regarding the extent and prospects of our several food crops, in the interests of consumers and producers no less than in that of commerce generally, is becoming more and more admitted. The county police, the relieving-officers, and the tax-collectors, have all been suggested as the agency by which the information sought might be most easily obtained. Mr. Caird now suggests, as a new agency, the engineers employed upon the Ordnance Survey. He proposes not that the whole country should be mapped out and allotted, but that certain characteristic plots, typical of the larger districts of similar soil and climate, should be selected. He supposes that Great Britain might be divided into 15 districts, and that 100,000 acres in each district might be taken as characteristic of it. These 100,000 acres would be laid down on the Ordnance Map, and subjected to an exhaustive inquiry. And the 1,500,000 acres thus investigated being about one-tenth of the cultivated land of Great Britain, would furnish the acreage and yield of their several crops, which, multiplied by ten, would supply us with trustworthy information of the gross agricultural produce of the country.

"Mr. Caird points out that there have been three objections hitherto urged to the collection of agricultural statistics:—

"I. The cost.
"II. The inquisitorial character of the inquiry.
"III. The difficulty of obtaining accurate returns.

"1. By the plan now to be submitted, the cost is not expected to exceed 3,000*l*. a year—an amount which, compared with the object, is not worth a moment's consideration.

"2. Neither the names nor the boundaries of individual farms will be known, and neither the persons making the inquiry, nor those to whom the results are communicated, can tell the precise farms to which the returns refer. The complaint of inquisitorial inquiry cannot, therefore, arise.

"3. The typical districts will be fixed quantities—say 100,000 acres each—laid down on the Ordnance Maps. Every acre within that limit will be exhausted, so that absolute accuracy will be attained.

"We believe that the more this subject is considered and discussed by intelligent agriculturists, the readier will they be to admit the advantage which the agricultural, as well as the commercial interests of the country, must derive from the information which the prosecution of Mr. Caird's plan must furnish."

Meanwhile it is satisfactory to know that a resolution affirming the importance and need of a national inquiry into the subject was the other day carried in the House by Mr. Caird.

The last subject to which we refer in our Agricultural Chronicle of the past quarter is the condition of rural cottages. Under the general question of the dwelling of the labouring class, this was lately made the subject of a conference before the Society of Arts, when a number of influential men united to consult on a remedy for the glaring evils which imperfect house accommodation inflicts. It was resolved, that much of the existing mischief is due to the Law of Settlement and the limited area of the Poor Law rating; that the tenure of property and the legal difficulties in obtaining sites are much in the way; but that—

"By proper attention to economy, by building to the extent only required by each district, and by the utmost care in avoiding unnecessary outlay in preliminary expenses, proper dwellings for the labouring classes can be provided which will realize in towns a fair dividend on the capital expended; and that although in rural districts, commonly speaking, the pecuniary return for capital invested in labourers' dwellings, considering the rate of their wages and their general circumstances, and the cost of repairs, can only be moderate, yet it may be regarded as satisfactory, when the consequent improvement of the character of the occupants, their comfort, their health, and the additional value of their labour are taken into account."

The chairman of the conference urged that, in the various Land Improvement Acts and in the Government Drainage Acts, there is ample precedent for Government loans, at a low rate of interest, for the express purpose of cottage improvement. And Mr. Akroyd, of Halifax, described the way in which, with the aid of building societies, no less a sum than 1,200,000*l*. had been spent in three towns of the West Riding, chiefly by the working men themselves, in the erection of good cottages, now or fast becoming the property of their tenants.

In agricultural districts where low wages interfere with the possibility of the labourer thus helping himself, there are especial facilities in the way of the landlord.

"The difference between the field and the garden-value of land is, in fact, the cottage-building landlord's great resource and help. Ten acres of land divided into large gardens for a hamlet of 20 or two-dozen new cottages may be worth but 15*l.* per annum to the farmers; they are, however, worth from 60*l.* to 80*l.* per annum to the tenants of the cottages. And the difference between those two sums represents a capital sum of 900*l.* to 1,300*l.*, which is a contribution of 30*l.* to 40*l.* per cottage towards the cost of their erection. Add to this the interest of the tenant-farmer in having labourers near their work, which should make him willing to bear his share of the annual cost of cottages upon the farm; and it appears to us that in country districts there is little real difficulty in the way of those owners of land who may lament the insufficiency of cottage accommodation on their land.

"The man-engine in the Cornish mine, by which half-an-hour suffices to take the miner to and from his work, in place of the hour or two at either end of the day wasted in climbing up and down the ladders, has added a full third to the efficiency of his labour. A cottage on the farm compared with one in the village three miles off, is like a man-engine in contrast with the ladders. A labourer fresh to his task can accomplish it more satisfactorily than one who does an hour's work before beginning it. And the tenant-farmer on this ground may well be expected to bear his share in the burden of supplying the cottages by which the value of his labourers is so much increased to him, and the profitableness of his farm is increased."

The plan adopted at Dumbleton by Mr. Holland, M.P., takes account of both of these considerations. A rent of 6*l.* pays a sufficient interest for the capital invested in the cottage. Of this, the cottager pays 3*l.* for the house and 1*l.* for the large garden; the farmer pays 1*l.* in consideration of the increased value of the man's labour; and the landlord pays 1*l.*, or rather cancels 1*l.*, because of the increased value which the estate possesses, or will possess, in the existence of a well-conditioned labouring population.

II. ASTRONOMY.

(Including the Proceedings of the Royal Astronomical Society.)

The progress of Astronomy during the past few months has not been characterized by such marked advances as those which will make the previous session long memorable in the annals of this science.

In Sidereal astronomy, while Krüger had found measurable parallaxes for two or three additional stars, the unwearied Goldschmidt was successfully engaged on the system of *Sirius*, and had been rewarded with the discovery of some other minute companions. In the solar system the advances in our knowledge were still more important. The necessity for a considerable augmentation of the sun's parallax had been established by so many different investigations, that it scarcely admits of further controversy, and there is little doubt that the correct value is now known within a very few hundredths of a second. The distance of Mars had been measured and delineated at the last opposition with an accuracy never before attempted. Mr. De la Rue, far from being content with the admirable results which he had obtained in celestial photography, had made additional and successful efforts for its further improvement. And, finally, the surface of the sun had been the subject of study to various astronomers, best fitted by their intelligence, their sharp-sightedness, and their command of appropriate apparatus, to extend our knowledge of this marvellous body. Nor are the different Observatories, both public and private, to be passed over in this brief review. At Greenwich the great Equatorial was employed during the past year in observations of the fixed lines of the stellar spectra, and recently the prism apparatus has been provisionally altered, so that, instead of producing astigmatic breadth of the spectrum by the unequal refractions of a conical pencil at the two sides of the prism, a pencil of rays made parallel by a lens traverses the prism, and, after being made convergent by a second lens, is made astigmatic by a cylindrical lens. The definition of lines appears to be improved, and the facility of measuring them increased. The same equatorial has also been used in observations of the Nebula of *Orion*, with results which show that the older drawing printed by Sir J. Herschel in the *Results of the Cape Observations*, 1847, is a more accurate representation of the appearance now presented by the Nebula, than the more recent drawing by Professor G. P. Bond. It is the opinion of the observers that Sir John Herschel's drawing represents as accurately as perhaps any drawing can, the appearances presented about the so-called jaws. According to this, there appears to be no valid reason for the supposition that the Nebula of Orion has been slowly altering its character of late years. At the Royal Observatory, Edinburgh, where time-signalling is one of the specialities, some important extensions have been made, and there were at the beginning of this session no less than seven separate time-gun signals fired in different cities in England and Scotland directly from the Royal Observatory, Edinburgh, whilst five more cities were in pretty active preparation. For short lines the system of explosion, based on the use of Professor Wheatstone's magneto-exploder and Mr. Abel's fuse, was found to answer perfectly, and it was also frequently successful between Edinburgh and Newcastle, a distance of 120 miles; but when the insulation was bad, by reason of fogs, the high intensity of the magnetic currents caused their loss and dissipation before reaching their destination. Hence a system was devised by which a current of electricity of low intensity was despatched along the line; and this, on reaching the town where the time-gun was placed, automatically liberated a current of magneto-electricity, which then passed along a covered wire for the short distance up to the time-gun. In the twelfth volume of printed Astronomical Observations lately issued from this Observatory, an addition of an unusual character is worthy of notice, namely, four plates photographic and one photoglyphic; the latter especially prepared for the occasion by Mr. Fox Talbot, the inventor both of photography and photoglyphy. The scientific reason for the introduction of these plates, which are highly magnified portions of some of the Teneriffe photographs of

1856, is the remarkable testimony which they bear to the transparency of the atmosphere, and its suitability to telescopic observation at great heights above the sea level. At the Radcliffe Observatory Mr. Main has been rigorously continuing observations of double stars with the heliometer. Most of these stars had been previously examined by Struve, the components being of nearly equal magnitudes, varying from about the sixth to the ninth; and Struve concluded that there was very great probability that the larger number, if not the whole of them, were *physically* and not *optically* connected. The results of the Oxford observations, thus far, do not confirm this idea, as in the interval of more than thirty years which have elapsed since Struve's observations, out of 190 systems examined, very few of the components exhibit any considerable motions in distance or position angle. At Cambridge, the regular work of an Observatory has been assiduously performed, and time has also been found for the ever-varying observations which special or seldom recurring phenomena demand, such as cometary observations, &c.; although from the absence of a first assistant, Professor Adams feels that the work of the Observatory during the past year has been seriously crippled. At the Liverpool Observatory, owing to local considerations, meteorology very properly claims the chief attention. Their new and most ingenious self-registering barometer has been in operation for about twelve months; the sheets on which the record is obtained are removed from the cylinder every morning at 9 A.M., and a tracing from the original, for the previous 24 hours, is forwarded daily at 10 A.M. to the Underwriters' Rooms, together with an account of the force and direction of the wind, the fall of rain, &c. The rating of ships' chronometers, always an important branch of the work of a sea-port Observatory, has here largely increased during the last year, and considerable alterations have been made in the method of giving the errors and rates. During the winter months each chronometer is exposed for a week to the temperature 50°, 65°, and 80°, alternately; and for whatever time the chronometer may be at the Observatory, the error is given at the end of each seven days, together with the mean rate and extreme difference of rate between any two days for each week. The latter, Mr. Hartnup thinks, shows the quality of a chronometer better than any other method he has been able to devise. At Mr. De la Rue's Observatory, Cranford, devoted almost exclusively to astronomical photography, observations have been made with silvered glass mirrors, as a less expensive and more reflective substitute for the speculum metal mirrors, and there is every reason to believe that the time of exposure of the sensitive plate will, by this means, be shortened. Mr. De la Rue has continued his experiments in enlarging his lunar negative to the dimensions of Beer and Mädler's map (38 inches), and has obtained results far surpassing those previously recorded. The Ely and Kew Observatories have been, during the past year, principally devoted to solar photography; a large number of solar autographs have been taken, and, by a comparison of the pictures taken simultaneously at each Observatory, it is anticipated that much information will be gained on the obscure subject of solar spots. At Ely, a large refractor of 6 inches aperture has been got into working order, and we may soon expect to hear that Mr. Titterton has succeeded in obtaining, by its means, solar autographs of 6 inches diameter.

The discussion on the phenomena in the solar envelopes, commenced by Mr. Nasmyth, is still occupying great attention. A question has arisen whether the general appearance of the photosphere is that of a flocculent precipitate, as suggested by Sir John Herschel, and assented to by Dr. Dawes, or whether it more nearly resembles a willow-leaved crystalline precipitate of detached particles, as originally described by Mr. Nasmyth and confirmed by Mr. De la Rue and Mr. Pritchard; and more lately Mr. Stone, with the large Greenwich refractor, has confirmed the existence of these strange entities, which to him appear like grains of rice. Although individual observers may therefore differ among themselves as to the exact shape of these particles, there appears to be no doubt that the sun's photosphere is covered with solid bodies, the immediate origin of the solar light, somewhat uniform in size and shape, the smallest of them having an area exceeding that of the British Isles!

Magnus * has lately recorded an experiment which, whilst it supports the lately propounded theory of Kirchhoff, on the constitution of the sun, in a striking manner, also appears to be quite concordant with the "willow-leaf" discoveries. It is well known that when a non-luminous gas-flame has a sodium compound introduced into it, the whole flame becomes brilliantly luminous with yellow light. Similarly, if lithium, strontium, or other metallic compounds are introduced into the flame, brilliant light of other colours is evolved. Now, Magnus has shown that the radiation of *heat* is also increased when these metallic vapours are rendered incandescent in the flame. The experiment was so arranged that a fixed spot in the soda flame was always compared with the same spot in the non-luminous flame, and care was also taken that the heat from the solid soda introduced into the flame, or from the platinum-wire which held it, could not radiate against the thermo-pile which served for the observation. The luminous flame radiated about a third more heat than when it was non-luminous. When, instead of soda vapour, a solid body, such as platinum, was brought into the portion of the flame experimented upon, a still greater radiation of heat occurred, and when the plate was covered with carbonate of soda the radiation increased afresh, and by keeping the flame likewise luminous with soda vapour the radiation of heat was increased three-fold. These experiments show that gaseous bodies radiate very much less heat than solids or liquids; it can therefore hardly be maintained that a gaseous or vaporous photosphere is the seat of the solar heat. The luminous- and heat-radiating particles in the yellow gas flame are therefore probably single torn-off particles of solid (or liquid) matter incandescent in the flame, and, comparing great things with small, they may be regarded as the counterparts of the willow-leaf particles in the solar envelope.

* 'Poggendorff's Annalen,' No. 3, 1864; and 'Phil. Mag.,' May, 1864.

Furthermore, it was shown * some years ago that, by holding one soda flame in front of another, the outer envelope of the front flame acted as an opaque screen to the brilliant yellow light radiating from the flame behind it; and that if this opaque part of the flame were introduced into the path of the light in a spectroscope, it would carve out of the most luminous portion Fraünhofer's double black line **D.** Furthermore, if other metallic particles were allowed to colour the flame (*e.g.* lithium, thallium, &c.) they would likewise act as opaque screens to rays of light of their own refrangibility, and would produce black lines, the exact counterparts of Fraünhofer's lines, in the solar spectrum. Now the portion of the flame possessing this great absorptive power is, upon examination, found to be a very faintly luminous exterior envelope, quite outside the luminous portion of the flame. Applying these facts to our theory of the solar envelopes, they fall into their places very naturally. The willow-leaves are the representatives of the atoms of incandescent metallic particles existing in our gas flame, whilst the highly-absorbent non-luminous outer envelope of the flame will represent the envelope of vapour which, on the sun's surface, is the cause of the phenomena of Fraünhofer's lines.

At one of the recent meetings of the Literary and Philosophical Society of Manchester, Mr. Baxendell brought forward an hypothesis, based upon an investigation of magnetical and meteorological phenomena, which confirms, in an unexpected manner, one of the most recent conclusions in theoretical astronomy. The results of the elaborate investigations of the motions of the planet Mercury, made by M. Leverrier, led that mathematician to attribute a certain unexplained excess in the motion of its perihelion to the action of a disturbing body circulating round the sun within the orbit of Mercury; and from a discussion of the probable mass of the disturbing body, he concluded that it could not be concentrated in a single planet, but that it consisted of a ring of small bodies, similar to that which is known to exist between the orbits of Mars and Jupiter. This ring, however, owing to its proximity to the Sun, may never be seen, and like the dark companions of Procyon and Sirius, it may only be known to us through its action on the other bodies of the system, of which it forms a part. An elaborate discussion of meteorological and magnetic phenomena has now led Mr. Baxendell to the suppositions—

1. That a ring of nebulous matter circulates round the sun in a plane nearly coincident with that of the ecliptic—the density of this ring differing in different parts.

2. That the attractive force of the sun on the ring varies inversely as the solar spots, being greatest when these are fewest, and least when the spots are most numerous.

3. The attractive force being variable, the dimensions of the ring and its period of revolution round the sun will also vary, their maxima and minima occurring respectively at the times of maximum

* "Crookes on the Opacity of the Soda Flame to Light of its own Colour." 'Chemical News,' vol. iii. p. 2.

and minimum solar spot frequency. By means of these hypotheses, our author explains many of the phenomena of the solar spots, the magnetic variations, the alterations of terrestrial temperature, and the changes in the direction of the wind. He has calculated that the greatest and least values of the sidereal period of revolution of the ring will be 29·12 and 22·08 days respectively. From these numbers we find that the greatest distance of the ring from the sun is 0·185, the radius of the earth's orbit being taken as unity; the least distance 0·154, and the mean 0·169. Taking Mr. Hind's value of the mean distance of the earth from the sun, namely, 91,328,600 miles, we have—

Greatest distance of the ring			=16,921,000 miles;
Least	„	„	=14,068,000 „
Mean	„	„	=15,494,500 „

and the range of movement to and fro, in a radial direction, =2,853,000 miles. The greatest attractive force of the sun on the ring being taken as unity, the least will be 0·691. Should future researches place the existence of this ring beyond doubt, this will, it is believed, be the first instance in which the conclusions of physical astronomy have been confirmed by the results of an investigation of magnetical and meteorological phenomena.

M. Faye * has given an account of a new method proposed by M. De Littrow, for determining the time and the longitude at sea. The method consists in the determination of the time by two circum-meridional observations of the sun, preserving at the same time the observation of the true noon for the latitude. The two altitudes may be taken at pleasure, on the same side, or on opposite sides of the meridian; the interval of time is arbitrary, varying according to the circumstances, from 5 to 30 or 40 minutes; and as the calculation takes only five minutes, the navigator may in half-an-hour take his observations, and effect all the calculations necessary for finding at once the longitude and the latitude. The new process depends on the fact that when, as at sea, a scrupulous accuracy is not required, the circummeridional altitudes of the sun may be used for determining the time. The method was tried on the voyage of circumnavigation of the Austrian frigate, the 'Novara,' and the results were generally correct, within a probable error of one or two nautical miles. This method might be equally useful on *terra firmâ* as at sea; for travellers, as well as for sailors, it would be useful to have a convenient method of determining daily their latitude and longitude, by observations concentrated at a single epoch of the day—about noon.

The Royal Astronomical Society.

In the 'Proceedings of the Royal Astronomical Society,' for March, Mr. Dunkin has given an interesting note on the number of luminous particles contained within a confined space on the sun's disc. The power used was about 100, and a system of wires in the

* 'Comptes Rendus,' March 7, 1864.

eye-piece of the telescope divided the centre of the field into nearly square spaces, the angular distance between the wires being 56″ in a vertical direction, and 48″ in a horizontal direction. The number of particles enclosed at one time within these spaces was estimated to be about 300, say about twenty in one direction, and fifteen in the other, and scattered equally about. As a deduction from these observations, Mr. Dunkin considers that the average length of these particles is about 2″, though there are some larger and many smaller. This observation was made on March 10th, but on repeating the examination on March 16th, the luminous particles appeared more thinly scattered, the number estimated to be contained in the nearly square spaces being about 200.

At the April meeting of the Royal Astronomical Society, the willow-leaved structure of the sun's photosphere was again brought forward, the Rev. W. R. Dawes affirming that the most recent observations had merely landed the different observers where he was sixteen years ago. In the beginning of the year 1848 Mr. Dawes, upon examining the disc of the sun by means of a transparent diagonal on Sir John Herschel's principle (power 65, aperture $6\frac{1}{3}$ in.), observed bright particles scattered almost all over the sun, which he then compared with two excessively minute fragments of porcelain. Four years afterwards, assisted by his new solar eye-piece, Mr. Dawes arrived at the conviction that these brilliant objects were not distinct entities, but were merely different conditions of the surface of the comparatively large luminous clouds themselves—ridges, waves, hills, distinguishable brightnesses—parts of the same luminous clouds which happen to be brighter than the other parts. These statements gave rise to an animated discussion. Mr. Pritchard suggested that Mr. Dawes might possibly have been impeded in the correctness of his observations, owing to the very minute aperture of his solar eye-piece; diffraction being likely to come into play to an inconvenient extent. Mr. Huggins thought that when a high magnifying power was used, the rice, or willow-leaved particles lost the uniform appearance which they have with a low power. At the same meeting a communication from Mr. Nasmyth was read, in which he gives four different forms of objects as he observed them. First, he draws the willow-leaves, No. 1; No. 2 is shorter, and a little wider; No. 3 is shorter still, and a little wider still; and No. 4 is exactly of the rice-grain pattern. No. 1 is the type of those forming the details of the penumbral strata; No. 2 is that which forms the details of bridges; No. 3 is the form which constitutes the other parts of the bridges in the margin of the photosphere. Both 3 and 4 may be said to be a type of those that may be seen over the entire surface of the photosphere.

Returning from the subject of willow-leaves to the other astronomical advancements during the past few months, we must not omit to mention the list of new double stars discovered by the Rev. W. R. Dawes. He gives a list of fifteen, and accompanies them by designation, full measurements, and remarks. Some, perhaps most of these, are only optically double, yet the example of that highly interesting binary couple, δ *Cygni*, may encourage the hope that other similar instances may be discovered. Mr. Dawes' No. 1 (p. xx. 177) was discovered in 1840, and occasional examination up to the present time has failed to show any perceptible change either in angle or distance. There would, therefore, appear to be no physical connection between the two, although, from the fact of one of its components having been examined by Struve, at Dorpat, and again by Maedler, without any notice of its being double, it seems almost necessary to conclude that it must have come out rapidly between 1832 and 1840. No. 5, η *Orionis*, is undoubtedly binary; it was regarded by Struve as single in 1826, and the distance has certainly increased during the last ten years, while the angles remain very nearly stationary. No. 8, L 2362, is an easy double star, but having been overlooked at Dorpat, and again at Poulkova, there is great probability of its turning out to be binary.

The recently discovered companion of Sirius has attracted some attention, both from the Rev. W. R. Dawes and from Mr. Lassell. The former observer has obtained distinct views of this object on two occasions, and obtained a measure of position with the parallel thick wires of the filar micrometer $= 84°·86$. The distance measure was estimated to be about 10″. Mr. Lassell has given five position measures, and six distance measures, each being the mean of six, the mean result being, position $= 79°·55$, distance $= 10''·12$.

Mr. Dunkin has made some remarks urging upon travellers to record, in their determinations of latitudes and longitudes by the sextant, not only the astronomical part of the observations of meridian altitudes, local time, or lunar distances, but the readings of the barometer and thermometer, at least once during each series of observations. The effect of this omission being to render it impossible to deduct the proper correction for refraction in computing the geographical position of the place. As an illustration, he gives the longitude of Kazé, computed from Captain Speke's sextant observations on Feb. 28, 1861. When corrected for refraction and parallax the longitude was 33° 1′ 0″ E.; and when uncorrected, 33° 17′ 0″—making a difference of 16′ 0″.

Two early observations of Uranus, by Bradley, which were brought, by Mr. Breen, before the March meeting of the Astronomical Society, are interesting. The first was on October 21, 1748, when it was observed as a star of the sixth magnitude, by the transit instrument; and the second on September 13, 1750, by the quadrant. The right ascensions are very accurate.

Some observations of comet VI., 1863, which was discovered by Professor Respighi, have led Dr. Weisse to remark that its path closely resembles that of 1810, giving a period of $53\frac{1}{2}$ years, in which case, reckoning back six revolutions, it would probably be identical with the comet of 1490, their paths having some resemblance. But Dr. Michez gives a set of elements, from several observations, in January and February last, which are better satisfied by an elliptic orbit, with a period of about $108\frac{3}{4}$ years. The identity of the comet with that of 1810 is thus doubtful.

A set of elements for the minor planet (79) Eurynome, has been calculated by Mr. W. A. Royers, from the Washington observations. They are fully given in the 'Monthly Notices, R. A. S.,' vol. xxiv. p. 126.

From some calculations communicated by Herr Theodor Oppelzer to the Astronomer-Royal, and published in the 'Monthly Notices' of the R. A. S., for April of this year, it appears that the identity of D'Arrest's and Pogson's planets can no longer be doubted. From the observations taken at Copenhagen, Berlin, and by Pogson himself, Herr Oppelzer has calculated a small Ephemeris. Astronomers will therefore, in future, regard (76) *Freia* = (80) *Sappho.*

III. BOTANY AND VEGETABLE PHYSIOLOGY.

M. Gris has made recently some experiments on the contents of the vessels of plants. He uses a liquid called the liquor of Fehling, which is usually employed for the detection of glucose. It consists of sulphate of copper, soda-lee (solution of caustic soda), tartrate of soda and potassa, and water, in definite proportions, and it preserves its limpid character when in a state of ebullition. When you add to it in a boiling state a very small quantity of glucose, there is produced a red precipitate of oxide of copper, which, when examined under the microscope, is seen to consist of very minute particles coloured deep brown or almost black. If in place of glucose some drops of sap are allowed to fall into the liquid, you obtain the same red precipitate of oxide of copper. If you immerse in the liquid for some time thick pieces of the wood of the Chestnut, Beech, Poplar, or Cytisus, in early spring, and cut thin slices for microscopical examination, you will notice an abundant precipitate of oxide of copper covering the inner surfaces of the large vessels, so that their course in the thickness of the woody layers may be traced by visible reddish thread-like streaks. As the same precipitate is very abundant in the cells of the medullary rays, M. Gris concludes that the vessels called lymphatic, contain (in spring at least) a sap analogous or identical with that found in the cellular elements of the same branch, and that the precipitate of the oxide of copper is probably determined in both by the presence of glucose. M. Gris thinks that the lymphatic vessels always contain liquid sap mixed with a more or less considerable portion of air.

M. P. Dalimier has performed a series of experiments from which he concludes that the vessels in the course of formation in the young tissues of plants may conduct the sap, but when they are completely formed,—the epoch at which they receive the names of porous or spiral vessels, &c., their normal condition is to contain air; they only contain sap in certain plants, and during a comparatively short time.

M. Belhomme has made experiments on the pollen of plants belonging to the Natural Orders Liliaceæ, Musaceæ, Araceæ, Amaryllidaceæ, Boraginaceæ, Solanaceæ, Malvaceæ, Cruciferæ, Passifloraceæ, Cactaceæ, Umbelliferæ, Myrtaceæ, Rosaceæ, and Leguminosæ; and he finds that in Dicotyledons the grains may preserve their fecundating property, under certain conditions, for a period varying from one to three years; whilst, in Monocotyledons, the period extends to six years.

The parasite called Cuscuta cassythoides grows at the Cape of Good Hope, on a species of Lycium, probably L. Afrum. It sends out long line-like branches, which entwine themselves firmly round those of the Lycium, and after one has established itself on a new branch, the connecting link between it and the old stock dies away, and a new plant is established on its own account.

M. Deherain finds that sulphate of lime, when introduced into arable land, does not assist the formation of nitrates or of ammonia, but that it acts by favouring the solubility of potash. According to him it transforms the neutral carbonate of potash into the bicarbonate which filters easily through the arable land. He gives detailed experiments and results in the 'Annales des Sciences Naturelles.'

In a paper on the variability of the Pear, by M. Decaïsne, given in the 'Annales des Sciences Naturelles,' the author maintains that there is no evidence of the degeneration of our fruit trees, in consequence of their continual propagation by grafting. The facts stated by those who contend for degeneration may be explained in various ways, such as climates or soils unsuited for the particular wants of the varieties, bad culture, or improper grafting. Our ancient pears, so justly esteemed for a century or two, are still the same as they were at first. The Crassane, Saint Germain, Doyenné, Chaumontel, Bon-Chrétien, &c., have lost none of their qualities. If they are neglected, it is only because cultivators are looking after novelties. M. Decaïsne also maintains that it is not true that the seeds of good varieties of fruit when sown in ordinary soil have a tendency to go back to a wild state, and produce crab-fruit. He says that no example has been produced of a good fruit fertilized by the pollen of its own flower or of other flowers of the same race, having produced seeds which gave origin to a wild plant with crab fruit. An esteemed variety fertilized by pollen from a variety with sour fruit may no doubt produce fruit of inferior quality; but every good variety, if it is only fertilized by itself, will produce good fruit. He says that we do not find the Canteloup melon returning, by being sown, to the small wild melon of India; nor our cauliflowers and cabbages taking on the form of the wild plants of the sea-shore. Species in the vegetable kingdom are endowed with great flexibility, the same specific type giving rise to races and varieties of very different aspects, but having the same morphological organization, and capable of uniting with each other by crossing, like the members of the same family. If we transport one of our races of pear to all quarters of the globe, we shall find that wherever it can live, it will have a tendency to put itself into harmony with the circumstances in which it is placed, and in course of time it will give origin to numerous new varieties.

Dr. Asa Gray, in the Proceedings of the Academy of Natural Sciences of Philadelphia, gives a synopsis of the genus *Hosackia;* and describes twenty-eight species, almost all of which occur in California. The genus belongs to the Natural Order Leguminosæ, and the tribe Trifolïeæ.

Dr. Asa Gray is satisfied that the two genera, Astragalus and Phaca, must be united, and that the genus Phaca must be merged in Astragalus. It is in the Botany of America that the distinction between Phaca and Astragalus is most pressing, and where the data for the answer are most largely to be found. While extra-tropical Asia is the focus of true Astragalus, that of Phaca is in America, mainly in North America, with an extension along the Andes into South America. While the Flora of the Russian Empire enumerates 168 species of Astragalus (of which more than nine-tenths are bilocellate or nearly so), and only six species of Phaca, Dr. Gray recognizes 66 species of the Phaca series, and 52 of Astragalus proper in America. Moreover, rather less than half of the latter are completely bilocellate by a dorsal septum, and at least half-a-dozen different groups have been or might be referred to Phaca. Dr. Asa Gray concludes that Phaca must be merged in Astragalus; and that since in perhaps the majority of Phacæ, there is no intrusion nor peculiar tumidity of the seminiferous suture, the subtribe Astragaleæ of De Candolle has no valid foundation, so that Astragalus is merely a genus of the Galegeæ. The question is also considered by Dr. Gray, whether Oxytropis should be kept a distinct genus. It is characterized by having along with the legume of Phaca, *i. e.* with the ventral suture septiferous, a beak-like acumination or cusp at the apex of the carina of the corolla, whence the generic name. Gray thinks that Oxytropis may still be kept up as a genus on the ground of general convenience, although the pointed keel has been detected in at least one species of true Astragalus (A. Nothoxys). He gives a complete revision and arrangement (mainly by the fruit) of the North American species of Astragalus or Oxytropis in a paper read to the American Academy of Arts and Sciences.

Hermann Hoffman, Professor of Botany at Giessen, has published a very useful 'Index Fungorum.' The names of all known Fungi and synonyms are given, with references to the works in which the plants are described.

From a paper by A. J. Malmoren, translated in Seemann's 'Journal of Botany,' it appears that the Phanerogamic Flora of Spitzbergen contains 95 species of plants.

Dr. F. W. Lewis, in the Proceedings of the Academy of Sciences of Philadelphia, has described some new species of Diatomaceæ. The gathering was made on the margin of a shallow pond, situated in the Notch Valley (White Mountains), from the southern end of which the river Saco takes its rise. The pond is about 200 feet long, and it is supplied by springs welling up from beneath the alluvial detritus forming the pond bottom, which overlies a stratum of clay, beneath which is the boulder drift. It is in the fine and soft mud, at from 1 to 4 inches below the surface, beneath and immediately around the waters of the pond, that the siliceous remains of the new species are most abundant. The gathering is principally remarkable for two points:—1. The striking analogy which exists between its species and those of the sub-peat deposits of the northern section of the United States. 2. The occurrence of several forms belonging to a known genus *Surirella*, so peculiar and variable in their characters as almost to merit the title of transitionary, by which is meant that these forms may be regarded as just such aberrant varieties of that genus, as we might expect to find conducting to the genera *Nitzschia* and *Synedra*, which in America seem to have followed the genus *Surirella*, at a long interval of time. They exhibit, moreover, such very unusual variation as to size, configuration, and definition of distinctive characters,—such want of generic fixity—as might be supposed likely to mark the incoming of new genera. Dr. Lewis describes the following new species:—*Surirella Baileyi*, *S. intermedia*, and *var.* β *S. anceps*, *S. delicatissima*, *Actinella punctata*, *Tryblionella* or *Denticula*, *n. sp.*, *Amphora intermedia*, *Navicula*, *n. sp.*, *Mastogloia elegans*, *Amphiprora pulchra*, *var.* β, which seems to be *A. conspicua* of Greville.

Principal Dawson has examined the Flora of the Devonian period, of North-east America, and he comes to the following conclusions:—

1. In its general character the Devonian Flora resembles that of the carboniferous epoch in the prevalence of Gymnosperms and Cryptogams; and, with few exceptions, the generic types of the two periods are the same.

2. Some species which appear early in the Devonian period continue to its close without entering the carboniferous; and the greater majority of the species even of the upper Devonian, do not reappear in the carboniferous period, but a few species extend from the upper Devonian to the lower carboniferous, and thus establish a real passage from the earlier to the later Flora.

3. A large part of the difference between the Devonian and carboniferous Floras is probably due to different geographical conditions. The wide, swampy flats of the coal period do not seem to have existed in the Devonian era. The land was probably less extensive, and more of an upland character. On the other hand, we find that the beds of the Middle Devonian, similar to the underclays of the coal measures, are filled, not with *Stigmaria*, but with rhizomes of *Psilophyton*.

4. The conditions in the Devonian period seem to have been less favourable to the preservation of plants than those of the coal epoch.

5. The Devonian Flora was not of a lower grade than that of the coal period.

6. The general character of the Devonian Flora, in America, is very similar to that of the same period in Europe. Yet the number of identical species does not seem to be so great as in the coal-fields of the two continents.

In a paper on the coal formation of North America, given in the

American 'Journal of Science and Arts,' M. Leo Lesquereux makes some important remarks in regard to fossil ferns. He says that the family of ferns was represented at the coal epoch by species which are easily referred to a very few typical forms. If we consider the figure of the leaves, *i.e.* their contour and venation, the only part generally preserved in the shales of the coal measure, all the species may be comprised in the three sections—Neuropterideæ, Pecopterideæ, and Sphenopterideæ. From the scarcity of fructified specimens of fossil ferns in the coal measures, it might be supposed that most of the species were without fruit. The want of fructification is rather casual than real. By careful examination at some places, where the remains of a species are found in abundance, one may generally succeed in finding traces of fructification. The sporangia seem in most cases to have disappeared, from long and continued immersion in water. Moreover, the fern fronds have usually the lower surface attached to the shale in such a way that the fructification cannot be observed. We can sometimes observe an indistinct outline of the form of the sporangia printed in relief through the carbonized tissue of the fronds. The scarcity of large stems would seem to lead to the conclusion that during the formation of coal, tree-ferns were of rare occurrence, at least when compared with the great number of ferns. If we consider as remains of true arborescent ferns, only those whose outer surface is marked by large oval cicatrices, and known under the names of *Caulopteris* and *Protopteris*, it is certain that they are very scarce in the coal measures both of Europe and of America. In his genera, Unger counts in the *Protopterideæ* of the coal, ten species only, distributed in five genera; and of these species, five are considered by Brongniart and Lindley as belonging to *Sigillaria* or *Lepidodendron*. Brongniart enumerates only six species of *Caulopteris*; Geinitz gives four, three of them published by Brongniart as *Sigillaria*, and one by Artis as *Megaphytum*; and Goeppert, in his 'Fossil Flora des Uebergangsgebirges,' has none. Some have supposed the genus *Psaronius* to be allied to *Protopteris*, and if so, the numbers of tree ferns would be much increased. Brongniart, however, looks upon *Psaronius* as allied to *Lepidodendron*. The cicatrices of *Caulopterideæ* are generally distant, placed on the stems in the spiral order $\frac{2}{5}$. When in a good state of preservation they are generally oval, or obovate, and elongated at both ends by a somewhat deep furrow. They have in the middle the mark of a simple bundle of vessels, in the form of a horseshoe, and the central scar is surrounded by an oval annulus. The genus *Megaphytum*, according to Brongniart, ought to be united with the genera *Bothrodendron* or *Ulodendron*, and referred to *Lepidodendron*, as representing merely a modification of the last genus. Lesquereux, on the contrary, considers *Megaphytum* as a tree fern, and he is led to this conclusion from an examination of the cicatrices of *Megaphytum protuberans*.

Messrs. Cloez and Gratiolet find that the gas exhaled from aquatic plants exposed to the light in ordinary water slightly impregnated with carbonic acid contains besides oxygen a notable quantity of nitrogen. The latter gas they consider as proceeding from the decomposition of the substance of the plant. They also maintain that the decomposition of carbonic acid by the green parts of aquatic plants, does not give rise to the formation of carbonic oxide as has been stated by Boussingault.

M. Cloez also says that the coloured parts of plants do not decompose carbonic acid so as to give off oxygen. If in some cases coloured leaves have been stated to do so, this depends he thinks on some green being present in them. He shows that in the coloured leaves of Amaranthus tricolor, the green portions only decomposed carbonic acid and gave off oxygen, while the yellow and red portions did not give off a single bubble of gas. These conclusions are contrary to the opinion of M. Theodore de Saussure.

IV. CHEMISTRY.

(Including the Proceedings of the Chemical Society.)

To chronicle with any degree of completeness the progress of a science which daily makes such advances as Chemistry, would require every quarter more than the whole of our space. We can only, therefore, continue to select those examples which seem to possess the greatest interest for general readers, and leave the special student of the science to seek the details in journals devoted entirely to the subject.

In general inorganic chemistry one or two interesting discoveries have been made. The first we shall mention is that of M. Lemoine, who has found that the red modification of phosphorus combines with sulphur in but one proportion.* The new sulphide has the formula $P_2 S_3$. It is a remarkably stable compound, having a distinct crystalline form. It is remarkable also that this compound is always formed, whatever the proportion of the constituents may be employed in the experiment. This sesquisulphide of phosphorus, as we must call it, is soluble in sulphide of carbon, which affords a ready means of separating it from the uncombined red phosphorus. The fact that one element in an allotropic modification combines with another element in different proportions to what it does in the ordinary state, may not be without some significance.

Proceeding with the inorganic elements, we must notice the discovery of the metal cæsium in an unexpected place. It is now some years since Plattner analysed Pollux, a scarce mineral found in the island of Elba. He pronounced it to be a compound of silica, alumina, soda, and potash; but in his analyses he always had an inexplicable loss. Recently, M. Pisani † has analysed the same mineral, and has discovered that it contains 34 per cent. of cæsium; and calculating for this metal, the amount set down by Plattner as potassium, the percentage sum of the constituents is exactly made up.

* 'Comptes Rendus,' May 16.
† 'Comptes Rendus,' May 18.

Next comes the discovery of thallium in the Nauheim spring, in which cæsium and rubidium also exist. Professor Böttger* announces that thallium is present in the saline residue of the water in an appreciable quantity; but Werther, who has also examined the residue, states that he was able to obtain but a mere trace in 4 pounds.† Professor Schrötter, of Vienna, announces that he has also found thallium in lepidolite and mica. There can be no doubt that this metal is widely diffused in nature; but the means occasionally employed to separate it sometimes suggests that the thallium may have been conveyed to the substance in the reagents made use of. Böttger supposes that thallium always exists in pyrites in the form of thallium-iron alum, a salt, the composition, properties, and crystalline form of which have been recently determined by Messrs. Church and Crookes, and Professor Miller, of Cambridge.‡ The existence of this alum is held to support the hypothesis that thallium belongs to the series of alkaline metals; but by the same reasoning, silver may also be proved to be an alkaline metal, since Professor Church has recently § made known the existence of a silver alum.

That the field of inorganic chemistry so far from being exhausted, is still capable of yielding rich results, has been once again proved by M. Marignac,|| who has discovered a remarkable series of silico-tungstic acids, and described their compounds. We need notice but one of these bodies, most noteworthy from the extraordinary density of the solution it gives with water. *Silico-tungstic acid* is formed when gelatinous silica is boiled with an acid tungstate of soda or potash. It is composed of one equivalent of silica and 12 equivalents of tungstic acid, and is a very stable compound, forming hydrates, which can be obtained in crystals of large size. When in combination with soda the salt gives an aqueous solution, having the specific gravity of 3·05; in this solution, glass, quartz, and most stones will float. The solution, notwithstanding its great density, is very fluid, and it has been suggested ¶ that it may form an excellent material for use in fluid prisms.

M. Kuhlmann has fallen upon some curious results in the course of investigations he has been led to make on the preservation of materials for building and ornamental purposes.

Some of these results are as important to geologists and mineralogists as to chemists, particularly those on the production of pseudomorphic crystals. By passing sulphuretted hydrogen over crystals of carbonate of lead kept at a moderate temperature, M. Kulhmann found that the carbonic acid in the compound was completely replaced by sulphur, while the crystal retained its original shape. Malachite treated in a similar way became converted into sulphide of copper,

* 'Proceedings of Manchester Literary and Philosophical Society,' March 22; and 'Journal für praktische Chemie,' No. 6, 1864.

† 'Journal für praktische Chemie, No, 7. 1864.

‡ 'Chemical News,' vol. ix. p. 205.

§ 'Chemical News,' vol. ix. p. 155.

|| 'Comptes Rendus,' May 2.

¶ 'Chemical News,' vol. ix. p. 238.

which retained the fibrous and veined appearance which belonged to the original mineral.* The same author has extended his investigations to the colouring matter of precious stones with some unexpected results. The amethyst, for instance, he finds to be coloured by some organic matter, and not by a metallic oxide. For the author's mode of analysing gems of various descriptions, and the results, we must refer the reader to the original paper in the 'Comptes Rendus' for March 28.

Mr. Sonstadt, who has already achieved distinction as a manufacturer of magnesium, has now turned his attention to calcium, and succeeded in obtaining this metal in a tolerably easy way.† He first fuses together iodide of potassium and chloride of calcium, and then adds the mixture to sodium, and continues the heat, which need not be great. This, as the author states, is only a modification—in which, however, a serious obstacle is avoided,—of the method proposed by Liès Bodart, and Bodin.

Lastly, in the department of inorganic chemistry, we must notice the production by M. Peligot of some useful alloys of silver and zinc. The French Government is about to reduce the standard of the silver coinage, which disappears from circulation in consequence of the scarcity of the metal. M. Peligot, who is chemist to the French Mint, suggests that zinc should be employed in the alloy instead of copper. One great recommendation of such an alloy is, that it does not blacken when exposed to sulphur compounds, nor furnish verdigris with acid liquids; it is therefore especially applicable for watch cases, jewellery, and coins. The best alloy we may say is composed of eight parts of silver and two parts of zinc.

Among the recently published results of investigations in the domain of organic chemistry, we may notice those of Cahours and Frémy on the respiration and maturation of fruits.‡ Cahours experimented upon apples and oranges, and found that when placed in a jar of oxygen or in mixtures of oxygen and nitrogen, the fruits absorbed the former gas and evolved carbonic acid. This went on and increased rapidly as the fruit ripened. In the expressed juices of the fruits he found carbonic acid and nitrogen, but not oxygen, hydrogen, or carbonic oxide. Further than this, he found that when the same fruits were placed in nitrogen or hydrogen, they still evolved carbonic acid, and the volume of the external gas increased. Hence the carbonic acid must have been produced by changes within the fruit and independent of the external atmosphere. The internal changes have been shown by MM. Chatin, Frémy, and Decaisne to consist in the oxidation of the immediate soluble principles. Tannin, it would seem, disappears first, then the acids, and lastly the sugar. These changes are well illustrated in the case of the medlar, which, when gathered, is very acid and astringent, and only becomes eatable after having been kept for some time in the air.

* 'Comptes Rendus,' May 17.
† 'Chemical News,' vol. ix. p. 140.
‡ 'Comptes Rendus, various, March, April, and May.

French chemists are still busily occupied with the phenomena of fermentation. The last experimenter who has taken up the subject is M. Béchamp, who attempts to show* that alcohol is a waste product of the yeast plant. His idea is that the plant first of all transforms sugar into glucose by means of peculiar ferment, which he calls *zymase ;* it then assimilates the glucose and grows; finally, it throws out the alcohol and other compounds usually called products of fermentation, just as animals throw out waste products such as urea, &c. As a confirmation of this idea, the author asserts that the yeast plant throws out alcohol when not in contact with sugar or any fermentable material.

At the commencement of the present year, Mr. Smith, of Edinburgh, announced the discovery of a new alkaloid, in the juice of fresh aconite root. He named it *aconella*, and stated that in composition and all its chemical properties it was identical with narcotine, one of the opium alkaloids. Recently, Professor Jellett, of the Dublin University,† has investigated the optical properties of aconella and narcotine, and found that in those the two alkaloids (or one) are identical. The extraction of one and the same alkaloid from two such dissimilar sources, is, to say the least, extremely curious.

Everything that relates to the Cinchona plant, and the valuable alkaloids derived from it, is of so much importance to us, that we cannot pass over the communication of Dr. De Vry, recently made to a meeting of the Pharmaceutical Society.‡ The author, who is the able superintendent of the Dutch Cinchona plantations in Java, has recently paid a visit to the British plantations in Ceylon, and on the Neilgherry Hills. He confirms the report that these are in a most flourishing condition, and he obtained at them numerous specimens of stem and root barks which he has submitted to analysis. The most curious result of these analyses is, that quinine is found in the largest quantities in the bark of the root, a statement quite in contradiction to that of our English authority, Mr. Howard. But so certain is Dr. De Vry of his accuracy, that he goes so far as to suggest the cultivation of the plant for the root alone.

In analytical chemistry some useful information has been furnished by recent writers. When sulphuric acid in combination with the alkalies is estimated in the form of sulphate of baryta, some alkali is always carried down, which it is impossible to wash out, and which exaggerates the amount of sulphuric acid. A writer in 'Silliman's Journal,' makes known the fact that the alkali may be got rid of by digesting the precipitate in a solution of acetate of copper strongly acidulated with acetic acid. The mixture should be kept near a boiling temperature for ten or fifteen minutes, then, after well washing, pure sulphate of baryta will be left behind.

Winckler has recently published a method by which in assaying tin ores, the metal can be easily obtained in a single button. After having separated other metals in the usual way, he mixes the binoxide

* 'Comptes Rendus,' April 4.
† 'Chemical News,' vol. ix. p. 216.
‡ 'Chemical News,' vol. ix. p. 237.

of tin with a known weight of peroxide of copper, and reduces the two metals together. The copper carries down the tin with it in a single button, and the weight of the tin is obtained by subtracting that of the copper producible from the oxide employed from the gross weight of the button.

In connection with sulphuric acid we may mention the fact that Mr. Bottomley, of Manchester,* has proved the inaccuracy of Pelouze's method of estimating sulphur in ores by deflagrating them with chlorate of potash and carbonate of soda, and then determining the amount of undecomposed carbonate by a standard acid. Some oxygen compound of chlorine would appear to be always evolved with the carbonic acid, and the percentage of sulphur is always too low.

Sulphur is an important remedial agent, and in no form is more effective than in a mineral water. Dr. Sheridan Muspratt has recently analysed the water of the Harlow-car spring near Harrogate, and found therein nearly four grains of sulphide of sodium in the gallon. This water will probably be as highly valued as that of the neighbouring springs at Harrogate.

An ingenious, and no doubt, a reliable method of estimating tannic and gallic acids, has recently been published † by Herr Mittenzwey. It is based on the capacity of these bodies for absorbing oxygen in the presence of an alkali. The absorption is effected in a closed flask, a tube from which is opened in water that this fluid may supply the place of the gas taken up. The water is taken from a weighed quantity, and each gramme sucked into the flask will correspond to a cubic centimeter of oxygen at the normal pressure and temperature. Modifications of this process, the chemist will see, are applicable for the determination of iron and manganese, and also the valuation of indigo.

In the applications of chemistry we have not much to report. A process of considerable interest has been suggested by Mr. Whitelaw, of Glasgow, for the utilization of the brine from salt meat. He submits this to dialysis, and thereby separates the salt, and obtains the juices of the meat for soup. A further application of the process will serve to procure salted meat in an approximate state of freshness. The meat and brine are placed together in a dialysing bag, which is placed in water for a day or two. In this time most of the salt will have passed into the water, and the meat will be left, not exactly like recently killed, but still available for cooking in a variety of ways, to which salt meat is not adapted.

Proceedings of the Chemical Society.

Most of the papers read at the meetings of the Chemical Society, are of interest only to advanced chemists, and could not possibly be made intelligible to the general reader, so we give merely the titles as a record of the Society's proceeedings. The first is a paper by

* 'Chemical News,' vol. ix. p. 200.

† 'Journal für praktische Chemie,' No. 2, 1864.

Mr. E. J. Mills, On Nitro-compounds; another is On Oxyaniline, by Dr. Schmidt; a third is On the Subformiate of Ethyl, and On the Basic Salts of some Organic Acids; others were On the Hexyl Group, by Dr. Wanklyn; On the Action of Hydrobromic and Hydriodic Acids upon Polyatomic Acids, and On the Behaviour of the Iodo-substitution Compounds towards Hydriodic Acid. Lastly, we may mention the profoundly interesting discourse by Sir Benjamin Brodie, On the Organic Peroxides theoretically considered.

Beyond this we have only to record the discovery by Professor Tuson of crystalline organic principles in castor and croton oils. Contrary to expectation, it would appear that these principles produce no aperient effects; but as the President of the Chemical Society remarked, they deserve fuller investigation.

V. GEOGRAPHY.

(*Including the Transactions of the Royal Geographical Society, and Notices of the Ordnance Survey of Great Britain and Ireland.*)

No science, probably, is more affected by political circumstances than geography. The development of mercantile speculation, war, and even the combinations and divisions of political parties and governments, each in their turn afford opportunities peculiar to themselves of acquiring fresh geographical information, and even of making some alteration in the physical contour of various countries. At the same time, it must be acknowledged that war especially throws many obstacles in the way of the investigation of distant lands; whilst mercantile pursuits not only interfere with those of a scientific character, but the spirit of greed that is apt to be developed where merchandize is a principle aim, frequently defeats its own object, and produces an exclusion from those very places which it was its desire to penetrate. As an instance of the service done to science by war, the insurrection in New Zealand has brought to light the great deficiency of good maps of that country. As the conquest of Seringapatam, by General Harris, led to the accurate survey and delineation of Mysore, so we may look forward to a lasting monument of the present unhappy squabble to be erected by the careful mapping out of the country traversed by the troops. The want has been strongly felt by the commanders, and it is to be hoped that they will take what means lie at their disposal to remedy the deficiency. In like manner we shall in all probability receive much additional information from some of the members of Mr. Eden's suite in his ill-fated expedition to Bhootan, and perhaps from the more military party that may have to follow in his footsteps. Under any circumstances, the north-eastern route to China is likely to receive some elucidation. But greater wars, such as the suicidal struggle in North America, on the contrary, paralyze all the efforts that used to be made on that continent. We have no longer any of those elaborate and costly works, issued by the War Department of the United States, which once were a credit to the government that encouraged their production. For fifteen years the American Government published from time to time records of exploratory work done for them, the greatest and best probably being those of the expedition up the Colorado river of the West. All that we now get from North America is from surveyors in British Columbia and Vancouver's Island. One distinguished citizen of the Republic, Mr. George P. Marsh, who is well known in this country for his works on the English language and literature, and who is an accurate and extensive scholar of Norse literature, has written a volume, entitled 'Man and Nature, or Physical Geography modified by Human Action."* The object of this work is to estimate in some degree the character and extent of changes produced on the physical globe by human action, and to suggest the possibility and importance of the restoration of disturbed harmonies and the improvement of waste and exhausted regions. The book is written in a popular style.

It is an extraordinary circumstance that the two continents, in some respects so remarkably similar, Africa and Australia, furnish us now with most of the topics on which geographers discourse. The practical problem of how to produce the greatest amount of wool of a fine texture, and of late a similar search for land on which to grow cotton, combined with an outlet for our surplus population, has led to several attempts to penetrate into various parts of the interior of Australia, not leading to any very astonishing discoveries, but at the same time gradually adding to our knowledge of the geographical, and, as a necessary consequence, the geological peculiarities of this continent. The interior of Africa affords more reasons and encouragements to the discoverer. The very profitable traffic in its peculiar productions is attractive to one class of minds, but many more are led on by a sort of romance, a desire to penetrate into the unknown, to live a wild life, holding in subjection nature and nature's children, to discover some of nature's secrets; whilst others again, and these, perhaps, not the least heroic, are tempted to try and disseminate the seeds of Christianity and civilization amongst the wild tribes, whom one at least of the savants of the present day believes to be incapable of higher cerebral development without incurring the risk of falling forward and becoming a rational quadruped! Thus these two continents, each with its extraordinary fauna and flora, running back into ancient geological periods, each of a somewhat similar geological formation, consisting of an external ring of mountains, and enclosing great central plains, with rivers running inwards, and either drying up or terminating in central lakes, are the points to which our attention is now directed.

The colony of Queensland, at the present time, owing to the war

* 'Man and Nature; or, Physical Geography as Modified by Human Action.' By George P. Marsh, author of 'Lectures on the English Language,' 'The Student's Manual of the English Language,' &c. 8vo. Sampson Low, Son, and Marston.

in New Zealand, and the disturbing elements of gold digging in the other settlements of Australia, attracts considerable notice. We shall have occasion to speak at a later period of the surveys conducted by the governor of this colony. The settlers seem anxious to open out all the means of communication that they can. There is a design for a mail to Batavia to join the Dutch here. The coast will soon be defended by several lighthouses. The climate seems to afford great relief to persons afflicted with chest diseases, and the dugong oil is as efficacious a remedy as that of the cod liver. The cultivation of cotton is making a considerable advance, and bids fair in time to succeed to the now lost Sea Islands. Tobacco, and other productions of both temperate and torrid zones, flourish, and the only problem that remains to be solved is how far *north* the European can live with impunity. The Society of Arts at home has offered a prize for the discovery and working of a new coal mine in Australia. This has afforded much amusement to the colonists. They have no lack of mines, and mines in convenient localities; but the competition is so great that the chief difficulty is to find a market for the coal procured. Queensland promises in a few years to become one of the most flourishing of colonies dependent upon this empire.

The African explorers have been of late pressing in upon the unknown central region from all sides. Some hindrances seem likely to stop their very rapid progress. Dr. Kirk, who was attached to Dr. Livingstone's party, has returned, and Dr. Livingstone himself, the report of whose death has proved untrue, is on his way to Bombay, *viâ* Mozambique and Zanzibar, hoping at the former place to sell his little steamer, the 'Lady Nyassa.' Bishop Tozer, who was settled on the Zambesi, appears to meet with less success than he had anticipated, in consequence of the disturbed state of the country, and recommendations are being forwarded to him to retire to the frontier land to the north of the Zulu land. His object is to advance towards the interior, and his route need not be confined to any river or line of march. M. Jules Gérard has met with a repulse, too, from the King of Dahomey. He was indiscreet enough to write to 'The Times' an account of the custom on the ascent of the present monarch to the throne, and in consequence he has been politely requested to retire from the kingdom which he had begun to describe.

Dahomey itself has suffered a remarkable reverse at the hands of the Egbas of Abeokuta, who were so well described in Captain R. F. Burton's book on that subject, published last year. The old grudge which the traveller mentioned as having been nourished for more than ten years, has at last broken out into active warfare. With troops to the number, it is said, of 10,000, of which a large portion were Amazons, he attacked the Aro gate of the extensive fortified enclosure of Egba villages, that go by the name of Abeokuta, Under-the-Stone, a confederation of towns that remind us not only of the four or five hills that were first enclosed to make up Rome with its allied tribes, but also gives an explanation of some of those peculiar plural names that many Grecian towns possessed. Niebuhr found an explanation of Janus Biceps in a town lying inland on the northern coast of Africa;

a future critic of Livy and of Niebuhr may probably find other analogies between the form and government of the city of the Seven Hills, and the rudely defended haunt of Egba robbers, Under-the-Stone. For the present their Alban or Veientine assailant has been repulsed, and the Capitol, Olumo, the builder, stands firm. Other rumours of wars come from this neighbourhood. War was being carried on, and it is to be hoped is now stopped, against the King of Ashanti. Little is to be gained by throwing away in the swamps of Western Africa the lives of Englishmen, valued in this country, in the almost vain hope of destroying the lives of a few score black fellows whose lives are accounted nothing worth in their own land. Such is the common argument against this war, the justice or injustice of which we have not seen discussed.

There are in this country ambassadors from Madagascar, and in France some from Japan. The former are described as gentlemanly, intelligent men, evidently accustomed to the European dress, and at ease in European society. The predecessors of the latter have lately published their ideas of our characteristics for the benefit of their fellow-countrymen. The introduction to their book has been translated, and it is to be hoped that before long the whole of this interesting narrative may be reproduced in this country. Naturally the differences between their habits and our own attracted their attention, and in this way we learn much of those peculiarities which are most difficult for us otherwise to discover. Thus the height and massiveness of our houses struck them as remarkable, and suggested great danger in case of earthquakes, betraying the secret of their own low and slight style of architecture. Partitions of paper supported by a few slight beams, topped by a shingle roof of the lightest material, would topple to pieces like a card-house at the slightest vibration, but at the same time would do as little damage as the cardboard edifice itself. Their ceremonious behaviour towards their friends of various ranks was so remarkably different from our own unceremonious nod, or even more dignified bow, that they could not but remark upon our utter want of common decency according to their ideas on this matter. Foreigners are not likely soon to be excluded from these islands again, for the Mikado, the spiritual ruler and representative of the Conservative feeling, has given permission for them to remain five years longer. The lower classes show quite as much good feeling towards strangers. A sailor, one of fifteen belonging to the 'Star of Peace,' who alone swam to shore after the wreck of that vessel and the capsizing of the long boat, was most hospitably received by the inhabitants at Kadsusa, and at length forwarded to Yokohama. It is to be hoped that this kindly spirit may not again be disturbed by any champion of British independence, and that some consideration will be shown for the feelings and customs of the natives. The Prussian Scientific Expedition, which was sent a few years ago to Japan and China, is now preparing for the publication of the results of its discoveries. The artist announces a series of views, which are to be issued at the expense of the King of Prussia, in parts, the first of which is ready, and embraces six large views of Yeddo.

Should the inhabitants of the wonderful island of Madagascar seek to enlighten their countrymen and their lately resuscitated king on the subject of the northern nations that they are now visiting, we, too, may hope to learn something of the ideas, manners, and customs of that almost impenetrable country, whose inhabitants, animals, and flora differ so materially from the nearest approaching continent. In the meantime, we must content ourselves with the scanty information contained in such books as the 'Journal of the Bishop of Madagascar,'* in which we get only incidental remarks of any geographical value, since the work is rather addressed to those who are interested in missionary labours, than to scientific inquirers. Amongst other little known localities, The Curieuse, the isle of Lepers, a hospital island whither all these afflicted creatures are consigned by the government of the Mauritius, was visited by the bishop in the discharge of his episcopal and missionary functions.

The Royal Geographical Society.

Some extremely interesting papers have been read before this Society during the past quarter, amongst which Mr. Gifford Palgrave furnishes one on a journey from Gaza, through the interior of Arabia to El Khatif on the Persian Gulf, and thence to Oman. Under the disguise of a physician, a Syriac Christian, Mr. Palgrave passed through a highly-interesting and little known region. He left Gaza on the 5th May, 1862, went some little way along the pilgrimage route from Damascus to Mecca, passed within two days' journey of the Gulf of Akaba over a desert inhabited only by lizards and serpents, and entered the kingdom of Jebel Shomer. Here commenced his most remarkable discovery, *viz.* that among the strictest Mahometans, and amidst the strictest kind of dissenters from the orthodox form of this religion, there exist remnants of the old superstition which the prophet of Islam intended to extirpate. The worship of the sun, of trees, of fire, and of the north star under the remarkable name of Iah, the same word as that revealed to Moses, as described in the book of Exodus, all find adherents in out-of-the-way parts of Arabia. Amongst the mountains these ancient forms still hold their ground. After ten days' journeying, Mr. Palgrave and his companions reached the capital, Haîl, where they were kindly treated by the king, Jelab. Haîl contains about 20,000 inhabitants, with a good market-place, handsome shops, and a grand palace surrounded by fortifications. The government of the whole kingdom is well organized, though it was only founded sixty years since. From this kingdom of Jebel Shomer, Mr. Palgrave next passed to that of the sect of the Wahabees, which sect originated with a fanatical Mahometan reformer, Mohammed Ebn Abd-al-Wahab, about 100 years ago. This kingdom is an

* 'Mauritius and Madagascar: Journals of an Eight Years' Residence in the Diocese of Mauritius, and of a Visit to Madagascar.' By Vincent W. Ryan, D.D., Bishop of Mauritius. Seeley, Jackson, & Halliday.

equally good specimen of official centralization, and is a remarkable instance of a complete despotism, both as regards religion and politics. The religious practices of the Wahabees or Wahabites, are very peculiar. With them the next most heinous sin that can be committed after polytheism, by which they mean any kind of idolatry, is what they term "drinking the shameful," by which they designate smoking. Compared with this, murder, theft, false witness, &c., are venial sins; but this is not to be expiated in this world. In consequence of neglect on this point, and in the matter of wearing silk dresses, the cholera was supposed to have invaded the province some six years ago, upon which the king thought it advisable to appoint a council of twenty-two members, the strictest and most religious men that could be found, to inquire into the religious observance and morals of the community, and to inflict such corporal punishment as they deemed fitting. The king's own brother, and one of the principal ministers, a sort of First Lord of the Treasury, suffered this castigation,—the latter to such a violent degree that he died the next day. All the inhabitants of the town are obliged to attend prayers five times a day on pain of a beating. They attribute every action performed by man, animal, or physical law, to no intermediate cause, but at once to the Deity himself. As an instance of this, Mr. Palgrave mentions that a boy who, by way of introduction exhibited some dexterity with a top, addressed them as follows:—"Not by my strength, nor by my cleverness, but by the strength of God, and by the cleverness of God." In this remarkable country, previously unvisited except by the victorious arms of Ibrahim Pasha, were found the most celebrated of the celebrated breed of Nejed horses. The colour of these was mostly grey, a few were white or chesnut, still fewer black, and none bay. They were beautiful beyond compare, with clean legs, delicate muzzles, graceful haunches, well set-on tails, and very sloping shoulders. The king had 130 in his stables, which Mr. Palgrave, in his character of physician, visited on more than one occasion. These horses never find their way to Europe, as they are never sold or bartered. Leaving this neighbourhood with extreme difficulty, owing to a quarrel with the king, whom Mr. Palgrave refused to supply with strychnine for the but slightly disguised object of disposing of his own brother and some others of the great men of whom he was afraid, the party arrived at Khatif, on the Persian Gulf. The journey thence was undertaken by the companions separately to Oman, at the mouth of the Gulf, where they visited and were well treated by the sovereign. They finally reached civilization and rest at Bagdad, after fourteen months' constant travelling.

Two interesting papers on the sister colonies of Vancouver's Island and British Columbia were contributed to the Society by Dr. C. Forbes, R.N., and Lieut. H. S. Palmer, R.E. The outlines of the coast of these two colonies seem to be similar, and to resemble the north-western coasts of Europe. A rugged sea board westwards, indented with numerous fiords, backed by undulating ground further inland, gives to the island as different an aspect on the two shores as England itself presents. In the colony, the gentler slopes lead on again to a second range of mountains, which develope at length into the Rocky Mountains. The climate in both cases is not vastly different from that of the Old Country, but the absence of the Gulf Stream, and the presence of currents from the Arctic regions, causes the temperature of the sea to be much colder than the ocean to which we are accustomed. In some respects the conchology is peculiarly boreal. Again, a great extent of snow-covered hill to the north of the colony causes cold but bright weather as late as Midsummer day. The principal wealth of both colonies seems to be mineral. Coal is found in some abundance in several places, and is of good quality. In British Columbia the principal attraction at present is the gold, which, according to Lieut. Palmer, promises the most inexhaustible field in the world. The veins appear to run north and south, but to be carried westward by the action of the torrents. The whole country produces magnificent forests, the trees of which reach enormous sizes; 300 feet is an ordinary height for a pine, whilst cedars reach the girth of 57 feet at a height of 5 ft. 6 in. from the ground. The country promises well for the farmer, being very similar in soil and production to our own land; but as yet there is little likelihood of much development of these resources, owing to the want of means of communication and the dearth of markets for the produce. A great number of Americans had emigrated to British Columbia, making excellent citizens, showing great enterprise, and exhibiting every disposition to settle permanently in the colony. The natives are, in the main, a peaceful and inoffensive race, though apt, if they consider their rights invaded, to retaliate in a manner consistent with the extremely degraded state of barbarism into which they have fallen.

Two papers on Queensland were read before the Society, one on an 'Overland Expedition from Port Denison to Rockingham Bay,' by A. J. Scott; the other was a communication from the Governor of the colony, Sir George Bowen, to the Duke of Newcastle, on the formation of a colony at Cape York, the northernmost point of the Australian continent, and on the survey of the inside of the Great Barrier Reef. The object of the former expedition was to discover a nearer approach to the sea from the Valley of Lagoons than Port Denison, which is 200 miles distant. Though no passage was made, an opening was discovered which only required that a certain portion of jungle should be cut through, in order to form a convenient road to the neighbourhood of Rockingham Bay. A continuous line of stations reaches northward of the Valley of Lagoons over a country well suited for Europeans, and for stock, and containing coal, iron, copper, and gold.

The Governor proposes a preliminary settlement on Albany Island, where the climate is remarkably cool for the tropics. There is abundant pasturage here for sheep, cattle, and horses, and large tracts for the cultivation of cotton, sugar, &c., and timber, stone, and lime exist in abundance. The survey of the inside of the Barrier Reef completes a most valuable and important work. It affords not only a safe means of communication between the colonies, but will undoubtedly in time become the route of the homeward-bound mails.

The reef acts as a natural breakwater, and keeps comparative still water within, the only disadvantage is the necessity of anchoring at night.

The subject of Nile discovery does not yet seem fully exhausted. Some of the reviewers of Captain Speke's book are inclined to dispute the fact of his having cleared up the whole mystery. The work of Phaëthon still remains uncancelled.

> "Nilus in extremum fugit perterritus orbem,
> Occuluitque caput, quod *adhuc* latet."

The captain is about to furnish further particulars in a pamphlet, entitled 'What led to the Discovery of the Source of the Nile.' In the meantime Mr. Petherick, late British Consul at Khartûm, has furnished the Society a paper on his journey with his wife and Dr. Muire up the Nile, from Khartûm to Gondokoro, in order to meet and assist the explorers. They sailed for some time up the river by the help of the north winds that blow continuously, but these at length failing, they were reduced to the necessity of making fast a rope to reeds, &c., and then hauling themselves along by means of this, being unable to tow from the nature of the river, which was here wide and shallow, and bordered by swampy marshes extending far inland. After proceeding some way in this manner, Mr. Petherick despatched an Arab whom he trusted, named Abd-il-Magd, to Gondokoro, to obtain tidings of Speke and Grant. Why he did not himself proceed on this expedition does not at present appear; and Captain Speke, in a letter to 'The Times,' complains that, as far as Mr. Petherick was concerned, he afforded him no assistance whatever; in fact, had it not been for his rival in trade, Mr. Debono, the East African expedition would have been considerably delayed, if not entirely frustrated. Mr. Petherick seems to have been deceived by Abd-il-Magd, who was carrying on a little secret traffic in slaves on his own account, and who returned without any news of the missing travellers. He reported indeed that obtaining no tidings at Gondokoro, he had gone thence westward to a place called Nyanbera, where the consul had a station, and from this place he had despatched some men southward, who were obliged to return in a few days, owing to the disturbed state of the country and their inability to procure better food than a few roots. These men report the existence of a large sheet of water flowing westward; but how much reliance is to be placed upon this evidence, we as yet know not. The rascality of Abd-il-Magd was soon discovered and properly punished. Mr. Petherick pursued his journey to Gondokoro, though he was obliged to travel by land westward in order to obtain porters, the demands for whom were exorbitantly high. He offered copper bracelets, but cows were required, and these were to be obtained only by a forage on territories of some of the neighbouring tribes, which he refused to attack. At last he procured both men and donkeys, and arrived at his own station at Nyanbera, and thence he proceeded eastward again to Gondokoro. Here he found Captains Speke and Grant already arrived, but of course he was too late to afford any material assistance; nevertheless, his name and the news of his approach seem to have influenced the African potentates in releasing their guests, who were glad to be rid of their misplaced hospitality. Until the return of the consul to this country, it will of course be impossible to judge of the endeavours he made to assist the course of discovery. In the meantime there seems to be a probability that Captain Speke may again be leaving this country for the interior of Africa, not only under the auspices of the Geographical Society, but with some material assistance from the Emperor of the French.

Three papers on New Zealand have been read before the Society. They all referred to the Middle Island; the first being an Account of an expedition to the west coast of the Middle Island by Dr. Hector; the second, a Survey of the lake district of Otago, by James M. Kerrow, Esq.; and the third, On the southern Alps of Canterbury, Middle Island, New Zealand, by Dr. Haast. The mountains described in the first and third of these papers are extremely interesting. They rise somewhat near the west coast: first, in hills covered with beech forests; then, white-blossomed willows succeed; after that, rocky boulders announce real mountain scenery. These New Zealand Alps are remarkable for their glaciers, and are said to present a counterpart of what Scotland must have been in what is called the glacial age. The snow line appears to be about 8,000 feet above the level of the sea, but is higher on the north-western side than on the south-eastern, the former being the side most exposed to wind, and also to the moisture collected by the wind in its passage over the ocean. But though the snow line is so elevated, the glaciers push down into the valleys as low as 3,500 feet above the sea. A glacier, named after Dr. Haast at the elevation of 5,500 feet, is 500 feet thick. Another, the Tasman glacier, is 12 miles long, and at its lower extremity is a mile and three-quarters wide. The mountains themselves frequently reach the height of 10,000 feet in isolated peaks. The highest, Mount Cook, is 30 miles from the west coast, and reaches the elevation of 12,460 feet (just that of the Adler Pass between Saas and Zermatt). The character of the chain is peculiar—a long ridge accessible at most points, though reaching sometimes 8,000 feet, interspersed with higher cols, forms the watershed of the island—the streams on the western side running in torrents to the sea, whilst the eastern flow more gently over a greater extent of plain, and passing through some extensive lakes, which act as locks to regulate the pace at which the collected waters make their way to the sea. Some of these lakes are of great extent. The Te-Anan and Manipori lakes drain a district of many hundreds of miles. They exhibit traces of much greater depth in former times, and in some cases the rocks run sheer down to the water from some hundreds of feet high. Great numbers of very beautiful trees are found in various localities, fuchsia and *tutu* growing to trees with trunks of two feet in diameter; beech, pine, and *totaru* being plentiful.

A low pass has been discovered over the Andes by Don Guillermo Cox, whose paper, translated by Sir Woodbine Parish, was read before the Society. 2,800 feet was the altitude at which the summit was reached. The discoverer equipped an expedition at his own cost at a German settlement called Montt, near the island of Chiloe, on the western coast, whence he proceeded towards the large lake of Naguel-huapi (Lake of Tigers). Here they found a river flowing eastward, which they descended; but at length their boat was capsized, and the party escaped, but only to fall into the hands of a cacique of a tribe of Pampas Indians, who wished to put Señor Cox to death, but was diverted from this by his playing on his flageolet. At last the cacique was induced to assist him as far as Rio Negro. The discovery was thus perfected, as well as that of a more northerly passage; but the utility of the discovery is at present dubious, in consequence of the hostility of the Indians.

This paper was followed by one on a railway over a northerly pass across the Andes, at a height of 16,500 feet, though a lower pass has been found a little southward; but this latter is not so practicable for engineering purposes.

Other papers read before the Society were, 'A Narrative of an Exploring Expedition into the Interior of Western Australia,' by Maxwell Lefroy, Esq.; 'An Exploration of the River Moisie to the Edge of the Table-Land of the Labrador Peninsula,' by Henry Yule Hind, M.A., Trinity College, Toronto; and one on 'The Frontier Province of Loreto, in North Peru,' by Professor Don Antonio Raimondy, of Lima.

The last proceedings of the Society that we have to record are the various ceremonials of the Anniversary Meeting. The report speaks of the pecuniary prosperity of the Society, notwithstanding very liberal grants to various travellers. The library and map room have received very considerable additions through the liberality of many donors. Premiums have been offered for instruments suitable for travellers, and a room has been set apart for the exhibition of such as are considered useful. The medals were this year presented—the founder's, to Baron von der Decken, for his remarkable journeys from the east coast of Africa to the mountains of Kilimandjoro, 20,065 feet above the sea level, and covered with perpetual snow—the patron's, or Queen's, to Captain Grant, the companion of Captain Speke, who last year was rewarded with the same recognition of his services whilst still at Gondokoro.

The President, in recounting the geographical discoveries of the year, descanted at some length on the discovery of the lake Victoria Nyanza, and other lakes connected with it or lying in the same region, and stated that the council had determined to offer 1,000*l.* towards an expedition up the White Nile, with a view of opening out the traffic with the interior, and extending the influence of the Pasha of Egypt in that direction, thus putting a stop to the horrors of the slave trade, which seems to infect all those who have commercial intercourse with the interior. Beyond this, the expedition is to explore the whole of this enormous lake (larger than Scotland according to Captain Speke), and gain all possible acquaintance with the physical geography of the neighbouring country. The President also gave a very elaborate account of the glacier system of the

Himalayas and the mountains of the Central Island of New Zealand, contrasting and comparing them with those of Europe, and showing their power in modifying the physical features of their respective regions.

The rule against the continued re-election of the same President has been suspended, and Sir Roderick Murchison again enters upon the duties of the office, which he has filled so ably during the past session.

The Ordnance Survey of Great Britain and Ireland.

By that large class who love good maps, the announcement that the Ordnance Survey of England is completed, and is soon to be within their reach, will be received with pleasure. This announcement is made in the Blue Book, reporting the progress of the National Survey up to the 31st of December, 1863; and in the course of another year or two, we may expect to have the maps of the six northern counties, which have been the last to be surveyed, issued to the public. These counties have the special privilege of being published on three different scales, namely, 25, 6, and 1 inch to a mile. It has always appeared to us that the first of these is unnecessarily large for a national survey, and is only justifiable for towns and special districts. For landowners it is, doubtless, a great boon to have a survey of their property made free of expense to themselves, and on a scale which would enable them to measure the breadth of a furrow in a ploughed field; but for the general purposes of the public such a scale appears absolutely useless, and we therefore maintain that the public should not be saddled with the cost of engraving maps from which they can derive no benefit. On the other hand, it may be replied that one survey is sufficient for any number of smaller scales, and that the measurements once taken for the 25-inch maps only require a proportionate reduction in the plotting for the smaller scales. Besides this, it seems probable that the produce of the sale of the 25-inch maps will ultimately cover the cost of publication; as the return of sale (including the value of those copies supplied to the public department) is set down for the past year at 2,135*l.* for England, and 2,624*l.* for Scotland.

The value of the maps on the 1-inch and 6-inch scales will not be disputed. As a matter of choice we should have preferred a 2-inch to a 1-inch scale, for the latter is so small in reference to the multiplicity of objects in populous districts that exaggeration and distortion cannot be avoided. This is particularly observable in laying down the turnpike roads, so as to distinguish them from country and parish lanes; on a scale of twice this size any undue enlargement would be unnecessary. We make these remarks because we feel satisfied that a re-survey of a large part of England will be undertaken on the completion of the whole kingdom. This is especially to be desired in respect of the southern counties of Cornwall, Devon, Wilts, &c., which were amongst the first to be surveyed, and the maps of which in point of execution are very far behind those now being issued under the able management of Colonel Sir Henry James and his assistants. Indeed, we can scarcely speak too highly of the typographical accuracy and artistic skill exhibited in the hill-shading, and general portraiture of the landscape features in some of the more recently published 1-inch maps of the north of England and Scotland, arising from the general advance in this art, and the great care bestowed on the work, both in the field and in the offices of the survey. But beyond all this, it is scarcely to be endured that the great manufacturing and mining districts of Staffordshire, Warwickshire, Derbyshire, and South Wales should be put off with maps on the 1-inch scale alone—while other counties which have no higher claim in point of industrial pursuits, or extent of population, have the advantage of maps on much larger scales. In the mining districts of Lancashire and Yorkshire the 6-inch maps are general favourites, and are very largely used for colliery purposes. For the mining districts of the central counties and Wales, similar maps would doubtless be most valuable, but in order to their completion new surveys will, we presume, have to be undertaken, and the proposition we venture to make is this, that along with the 6-inch maps, others on a scale of 2 inches to a mile be published simultaneously. The 1-inch maps, both of the Geological and Ordnance Surveys, might of course remain as they are.

In Scotland the progress of the survey has lately been rapid, in obedience, we may suppose, to the demands of some of the Scotch Members of Parliament. The whole of the Lowlands, with the Highland districts of Perthshire, are surveyed, and are in course of publication on the three scales of 25, 6, and 1 inch to a mile. What may be the object of publishing parish maps of Highland moors and mountains on the 25-inch scale we cannot devine, except perhaps for the purpose of defining with accuracy the lands beyond which neighbouring sportsmen would be liable to penalty for trespass. It strikes us, however, that the 6-inch scale might have been sufficiently large for this purpose. Speaking from experience, we have never found any difficulty when traversing the moors of the north of England with the 6-inch map for a guide, in ascertaining exactly when we passed from one peat-bog to another across the narrowest possible ditch or line of demarcation, and in determining with certainty our position on the ground.

As regards Ireland, the plans of every county have been engraved and published on a scale of 6 inches to a mile, but as the plans of the northern counties, which were first surveyed, were made without that amount of detail which is now found necessary for the local valuation and assessments, these maps are being revised "at a great additional expense." Hence, as is frequently proved to be the case, it would have been cheaper in the end to have done the work well at the beginning. The whole of the 1-inch map is engraved and published in outline, and the engraving of the hills is being proceeded with.

Maps of most of the cities and towns of any importance in the three kingdoms are published, or drawn, on scales of 5 feet, or 10 feet to the inch; these have been proved most useful for the purpose of sewage, water supply, repairs, and valuation. The following is a summary of the present state of the Ordnance Survey publications :—

ENGLAND.—Area, 58,000 square miles.

The whole has been surveyed, and, with the exception of a small part of the northern counties, is published on the 1-inch scale. The 6-inch maps of Lancashire, Yorkshire, Westmoreland, and Durham, containing 9,743 square miles, have been published; the engraving of those of Northumberland and Cumberland is far advanced. The six northern counties, and the southern counties of Essex, Hampshire, Kent, Middlesex, and Surrey, are being published on the scale of 25 inches to a mile.

WALES.—The whole principality is published on the 1-inch scale.

SCOTLAND.—Area, 30,000 square miles.

The 1-inch maps, with hill shading, have been published to the extent of 5,047 square miles, belonging principally to the shires of Ayr, Wigton, Kirkcudbright, Dumfries, Edinburgh, and Haddington, and the Isle of Lewis; while the whole of the tract south of the Friths of Forth and Clyde is engraved in outline.

On the 6-inch scale nearly the whole of the district south of the Friths of Forth and Clyde has been published, with the exception of parts of the shires of Renfrew and Lanark. Besides these, parts of Fifeshire and the Isle of Lewis have been completed, making in all 7,652 square miles.

On the 25-inch scale, plans of parishes for the counties of Ayr, Berwick, Dumbarton, Dumfries, Lanark, Linlithgow, Peebles, Renfrew, Roxburgh, and Selkirk, have been published.

Besides the above, the maps of Perthshire and Stirlingshire are in course of preparation, and the surveyors are carrying on their field-work amongst the highlands of Aberdeenshire and Argyleshire.

IRELAND.—Area, 32,813 square miles.

The outline maps on the 1-inch scale have been published for the whole country. The hill shading of these maps is in progress, and an area of 3,557 square miles belonging to the counties of Donegal, Londonderry, Meath, and Dublin has been published.

With reference to the 6-inch maps, it has been already stated that they have been completed for the whole country, but that those of the province of Ulster have been found to require revision. This has been, to a great extent, accomplished.

VI. GEOLOGY AND PALÆONTOLOGY.

(*Including the Proceedings of the Geological Society.*)

WHILE new facts are generally more or less plentiful in all sciences of observation or experiment, new theories worth anything are few and far between, at any rate in Geology; and although every new fact must be to some extent an advance, a new theory may be, and often is, the cause of a decided retreat. But if a theory can withstand such a test as a well-directed effort at its proof, it may be considered an advance in science, as also may one which explains, or assists in explaining, in a rational manner, causes of phenomena hitherto obscure.

Of the many geological phenomena whose causes are still more or less obscure, that of the elevation and depression of portions of the earth's crust is one of the greatest importance, because of its being an element of change always present in the mind of the geologist, and one of the greatest difficulty because of the protean character of the circumstances attending its production, as well as on account of the numerous secondary results of which it is the proximate cause.

A new theory of elevation and depression has recently been propounded by Professor Bischof (in a second German edition of his 'Lehrbuch der chemischen und physikalischen Geologie'), who considers that all the observed phenomena can be explained by supposing them to have resulted from an increase or decrease of volume in deeply-seated rocks, in consequence of the more or less complete displacement of the silica of their silicates by carbonic acid. The chemical action and the physical result, which are together believed by the author to be the cause of the phenomena in question, may conceivably take place in nature, as we know that they can be produced by experiment.

Geologists have long been aware that the greater portion of the Scandinavian area has for ages been gradually rising at the rate of a few inches in a century, and this circumstance has hitherto baffled the ingenuity of every one who has attempted to explain it. But Professor Bischof's statement that the country is undergoing this upheaval only in those portions of it where siliceous rocks occur, renders it very probable that his theory will apply to a case of this kind, for he would scarcely make a statement of such importance had he not ascertained the fact to be such as he represents it. In a similar manner he explains the sinking of Greenland, the hydrous silicates which occur there undergoing a loss of volume through the displacement of the silica by carbonic acid.

It is, therefore, very probable that Professor Bischof's theory may be found to apply to such cases of gradual upheaval and depression, and thus it is surely a great advance in our knowledge of geological causes. Had the distinguished author been contented with this limited application of his hypothesis, we should not have been disposed to cavil at any of his arguments; but when he strives to account for the dislocation, contortion, and overturning of strata by merely supposing the upheaval to have been of unequal amount in different places, we confess that we are more than sceptical. It is easy for a chemist in his laboratory to propound such an hypothesis, but it is equally easy for a geologist in the field to see that it is very improbable, if not impossible.

Leaving now the region of theory, we may remark that the first announcement of a new and startling fact is often a much less important episode in the history of its discovery than the first attempt at its confirmation. The case which we are about to notice, namely, the discovery of fossils in the Laurentian rocks of Canada, well illustrates this proposition, for when the announcement was first made by Sir William Logan, nearly five years ago, at a meeting of the American Association for the advancement of science,* that one of the geologists of the Canadian Survey, Mr. John M^cMullin, had found some specimens in the Laurentian formation of Ottawa, which appeared strongly to resemble the fossils from the bird's-eye limestone known under the generic name of *Stromatocerium*, the statement, though printed in most of the scientific journals, received but little credence; but now that it is made for the second time, it has attracted the attention of most palæontologists, and won the belief of not a few.

One of the original specimens is figured in Sir William Logan's 'Geology of Canada,' and, as he observes, it certainly bears a wonderful resemblance to *Stromatopora*, which genus, we believe, is now thought to belong to the class *Polyzoa*. The Geological Survey of Canada has recently, however, had the good fortune to find other specimens of the same, or a similar organism, in the serpentine-limestone of Grenville; and as these specimens have been carefully prepared for a rigid examination, which has been undertaken by Dr. Dawson, F.R.S., F.G.S., who is well known as an able investigator of the minute structure of fossils, and who considers them to be *Foraminifera*, there appears to be no longer room for doubt as to their organic character, though until Dr. Dawson's figures and descriptions are published, the place they really occupy in the animal kingdom must remain uncertain.

The Laurentian rocks of Canada are older than any of the British strata, with the exception, perhaps, of some masses of granitic gneiss, which are supposed by many eminent geologists to be their equivalents, and which occur in the extreme north-west of Scotland and in the neighbouring isles. This statement may give some idea of the antiquity of the fossils, but their date is even more remote than would be supposed from a comparison of that nature, for Sir William Logan has recently discovered that the Laurentian system consists of two great groups, the upper of which—the Labrador series—rests unconformably upon the more ancient or Laurentian series, and it is in the latter that these fossils have been found. Below the whole series of British stratified rocks and their unconformities it is therefore necessary to add the Labrador series, then another unconformity, and another great series of rocks, and not until then do we arrive at the geological position of these old *Foraminifera*.

There is yet another point of interest connected with these ancient organisms, namely, their mineralization, Mr. Sterry Hunt having determined the substance which was formerly supposed to replace the calcareous skeleton of the animal, but which is now known to fill up the interspaces, to be true serpentine; so that, although it was pretty certain before, there can now be no doubt whatever that that rock is sometimes of metamorphic origin.

In a recent memoir, M. Alphonse Milne-Edwards discusses the 'Geological Distribution of Fossil Birds.' Although most of the fossil remains of birds hitherto discovered have been found in Ter-

* *See* 'Canadian Naturalist and Geologist,' vol. iv. 1859, p. 300.

tiary strata, yet they are known to have existed at a period as early, perhaps, as that of the Connecticut sandstone, the footprints so abundant in that rock exhibiting characters such as belong normally to this class only; but inasmuch as bones of birds have not yet been found in the same rock, the fact of the existence of such animals at this remote period, can scarcely, as yet, be considered established, although Professor Dana, in analysing a coprolite discovered near the footprints, found in it so large a quantity of uric acid as to render it probable that it had been formed by a bird.

If birds existed in the Triassic periods, their descendants or allies, must have lived during the deposition of all the succeeding strata; and, until the discovery of the *Archæopteryx*, this was the only reason that could be given for supposing them to have existed during the Jurassic epoch. The discovery of that noted fossil supplied a link, until then wanting, in the life-history of the class, and thus rendered the probability of the Connecticut footsteps being due to birds much greater than it was before, by diminishing, in a wonderful degree, the gap between the two oldest known indications of ornithic life. The *Archæopteryx* has been described scientifically by Professor Owen, and popularly by a dozen or so of *soi-disant* ornithologists, so that further notice of it need not be taken here.

Most of the bones of supposed birds found in Cretaceous strata have turned out to belong to other classes of animals, and in their investigation even Professor Owen appears not to have been free from error, as he described, under the name of *Cimoliornis Diomedeus*, some remains found by Lord Enniskillen in the chalk near Maidstone, which were afterwards shown by Dr. Bowerbank to be reptilian, and probably to belong to *Pterodactylus giganteus*. The result at which the author arrives is that the only undoubted evidences of Cretaceous birds are—(1), Their remains discovered by the late Mr. Barrett in the Cambridge Greensand; and (2), Those cited by Mr. Harlan from the Greensand of New Jersey.

Respecting the ornithic fauna of the Tertiary period, it must be sufficient to remark that remains of about 12 genera, represented by many species, have been found in the Paris Basin, besides at least seven kinds of tracks; and that the Miocene and later strata have afforded still more numerous remains, and the author of this paper indicates in it the characters of twelve new species from the Miocene strata of the Limagné. It must also be remembered that while a single species is of great interest when it constitutes all that is known of a fauna, it sinks into comparative insignificance when it forms, perhaps, but the fiftieth part of a known population.

M. Alphonse Milne-Edwards concludes his paper by observing—(1) That the existence of *Gastornis Parisiensis* and of the imprints of gigantic feet in the Paris gypsum shows that during Eocene times there existed a fauna at least as perfect as that of the recent period; (2) That the birds of the Miocene period differed but little from those of the present day, certain families, however, such as the *Phœnicopteridæ*, which are scantily represented now, being rich in genera and species then; and (3) That in the Quaternary period only the fauna of the present day existed, such extinct species as occur in deposits of that age having since disappeared through the agency of man.

Dr. Duncan has given in full the results of his researches on the Fossil Corals of Scinde, in a paper which appeared in the April number of the 'Annals and Magazine of Natural History.' He finds that of forty-two species occurring in the Hala mountains, in Scinde, and in Cutch, fourteen of which are new, at least eleven species are not of Eocene date, notwithstanding that MM. D'Archiac and Haime appear to have ignored the occurrence of coral-bearing Miocene strata in the great chain of hills extending from the 'Salt-range' almost due south to Kurrachee, as they referred all such beds to the Nummulitic formation. It has for a long time been suspected that this so-called Nummulitic formation of India might include a later Tertiary deposit, as was originally determined by Messrs. Grant and Sowerby, and from what has recently been done it appears that there is now very little doubt as to the correctness of this view, notwithstanding the assertions to the contrary made by MM. D'Archiac and Haime in their great work on the fossils from the strata in question.

Mr. Searles Wood, jun., has this quarter published another contribution to the literature of the more recent strata, in continuation of those noticed in the last number of this Journal. From his researches, as detailed in his memoir "On the Belgian Equivalents of the Upper and Lower Drift of the Eastern Counties," published in the 'Annals and Magazine of Natural History' for May, it appears that the sands and gravels underlying the Boulder-clay in Norfolk, Suffolk, and Essex, to which he has given the name "Lower Drift," are probably the equivalents of the Campinian sands of Belgium; and that the Boulder-clay, or "Upper Drift," is the equivalent of the Loess of Belgium and the Rhine. This view differs essentially from that taken by many eminent geologists respecting the correlation of these deposits, and as the question rests entirely on stratigraphical and physical considerations, it can be discussed only by those who possess very considerable local knowledge of the deposits.

Mr. Wood's papers have, however, placed the matter on a footing somewhat different from that on which it rested previously to their publication, for he has applied the terms "Upper Drift" and "Lower Drift" to deposits which have until now been confounded together, with other more recent accumulations, under the general title of "Drift." So indefinite has been the meaning attached to this word "Drift," in respect of the age of the deposits to which it has been applied, that Mr. Wood does not appear to have been quite happy in his choice of terms; for if we confine the application of the term "Upper Drift" to the Boulder-clay, and of that of "Lower Drift" to the sands and gravels between it and the Red Crag, which have never before been treated of as a distinct deposit, what are we to call all those accumulations of sand, gravel, and clay, which are newer than the Boulder-clay, and to which the term "Drift" has hitherto been more commonly applied?

Proceedings of the Geological Society.

The last number of the Quarterly Journal of this Society can scarcely be said to be "full of interest" in other than a purely technical sense; but the Anniversary Address of the President, Herr von Koenen's paper on Oligocene Deposits in England, Professor Hind's remarks on Glacial Drift, and a memoir on Permian Rocks, by Sir R. I. Murchison and Professor Harkness, all contain matter of general interest; we shall, therefore, notice them first, and then discuss the Annual Report of the Council.

1. Professor Ramsay's Anniversary Address is prefaced, as usual by the award of the Wollaston Medal and Donation-fund, the former of which was this year given to Sir R. I. Murchison; and were it not for the President's explanation—that the distinguished recipient had served uninterruptedly on the Council of the Society for thirty-two years, and was thus prevented from having conferred upon him before an honour he so well deserves—we should have marvelled at the omission. The accident of his temporary retirement from the Council, as one of its senior members, has been well and gracefully taken advantage of by his associates for the purpose of showing their appreciation of his vast services to geology in a manner so agreable to himself.

The Address itself is a continuation of that of last year, noticed in the last number of this Journal. As on the former occasion, Professor Ramsay discussed the "Breaks in the Succession of the British Palæozoic Strata," so in this Address he treats more especially of the "Breaks in the Succession of the British Mesozoic Strata;" but there are some collateral subjects discussed first, to which we must refer for a moment.

The first subject is that of the "Commencement of the Prevalence of Secondary Genera in Carboniferous Times," and it is certainly a remarkable one as treated by Professor Ramsay. Every disbeliever in cataclysms and sudden great creations must have long been familiar with the idea that some of the secondary genera appeared by degrees for the first time during some one or more of the Palæozoic periods; but, so far as we know, it has never before been shown what great fauna contains the first faint indication of secondary types. We may be certain of the existence of a needle in a haystack, but few of us have the energy or the skill to find it. But it is just such an operation as would be required in that case, that Professor Ramsay has performed with the vast mass of Palæozoic genera.

Referring, next, to the enormous lapse of time between the Permian and the Trias, as evidenced by "the disturbance, contortion, partial upheaval into land, and vast denudations which the Palæozoic rocks underwent before and during the deposition of the New Red Sandstone in the west of Europe," and as sufficient reason why there should be so great a difference between the fauna of the latest Palæozoic period, and that of the earliest Secondary epoch, Professor Ramsay then discusses the relations of the faunæ of the different Secondary formations and their subdivisions. He bases his arguments upon the percentages of species common to the formations next in time to one another, as shown in tables perfectly bewildering in their complexity, and according as he finds them great or small, aided by stratigraphical considerations, so does he infer the existence or non-existence of an unconformity or of a break between them.

The two principal breaks shown to exist are—1. That between the Bunter and Keuper strata—represented on the continent by the Muschelkalk and the St. Cassian beds; and—2. That between the Oolitic and Cretaceous formations, which is represented, wholly or in part, by the Wealden and Purbeck beds.

In conclusion Professor Ramsay enunciates a general principle which he has inferred from his researches on breaks in succession, as follows:—"Making, as we can often do, all liberal allowances for diversities of marine and terrestrial conditions, I cannot resist the general inference that, *in cases of superposition, in proportion as the species are more or less continuous, that is to say, as the break in life is partial or complete, first, in the species, but more importantly in the loss of old and the appearance of new allied or unallied genera, so was the interval of time shorter or longer that elapsed between the close of the lower and the commencement of the upper formation;* and so it often happens that strata a few yards in thickness, or, more notably still, *the absence of these strata*, may serve to indicate a period of time as great as that represented by the vast accumulations of the whole Silurian series." Let him now calculate the age of the world who can.

2. Herr von Koenen's short paper, "On the Oligocene Deposits of Belgium, Northern Germany, and the South of England," is the result of a visit made by the author—a young German geologist—to the Isle of Wight and Hampshire, during which he managed to show, by means of fossils collected by himself, that certain strata known as the Middle Headon beds, which contain freshwater shells in the Isle of Wight, but marine fossils at Brockenhurst, belong to the Lower Oligocene formation of Germany. Of course Herr von Koenen advocates the adoption of Professor Beyrich's term "Oligocene," on the propriety, or rather the necessity, of which opinions are divided in England, but the question is too complicated to be discussed in an abstract. However, the paper shows us that in that often-explored region—the Isle of Wight and Hampshire—the young geologist may still be rewarded by making discoveries of interest.

3. In his paper on "Supposed Glacial Drift in the Labrador Peninsula, Western Canada, and on the South Branch of the Saskatchewan," Professor Hind describes phenomena, some of which occur on so grand a scale that, paradoxical as it may appear, they would be overlooked by the ordinary observer. Many of these phenomena have resulted from the operation of the forces that produced the present physical configuration of the surface. Of this nature are the terraces so abundant in the line of country between Lake Winnipeg, and the Grand Côteau de Missouri, in which region occur several precipitous escarpments facing North or North-east, the opposite face of the mountain always consisting of gently sloping plateaux separated by

terraces. These escarpments, though hundreds of miles in length, are all roughly parallel to one another, and appear to have a common origin. The author considers that they are all due to glacial action in some form or another, and he adopts Mr. Jamieson's explanation of the origin of the Parallel Roads of Glen Roy to account for the formation of the beaches and terraces of North America. The probability of their not being due to the action of the sea is increased by a very curious fact, namely, that in the state of Wisconsin there is an area of more than 3,000 square miles in extent, which is perfectly barren of drift and terraces, and in which no organic remains have been found other than those of Palæozoic rocks, with the exception of those of land-animals and plants. The inference drawn from these facts by the geologist who explored the region—Professor Whitney—was that this area has not been submerged since the Upper Silurian period. If this be so, of course the terraces, beaches, and drift in the neighbouring regions could not have been the result of the action of the sea, but must have been produced by a local cause; and the same inference will hold good if it can be shown that the driftless area of Wisconsin has remained above the level of the sea ever since the close of the Pliocene period, a conclusion much more likely to be accepted than the larger inference of Professor Whitney. The remarkable abundance of erratics in the regions described renders their absence in the "Driftless Area" still more singular, although in the valley of the Moisie they appear to be entirely wanting at less heights above the sea than 1,000 feet.

Professor Hind endeavours to explain all the phenomena, including beaches, terraces, escarpments, lakes, striæ, &c., as well as the forced arrangement of blocks of limestone (at an angle of about 45°) in Boulder-clay, by reference to ice-action, either direct or indirect; and he also reminds us that he promulgated the view that the great lakes were excavated by ice in the year 1859. His views regarding the particular form of ice-action by means of which lake-basins have been excavated appear rather improbable; he supposes that anchor-ice, formed in the rapid streams issuing from glaciers, may have begun the excavation by floating masses of rock from their beds to the surface, and that the glacier itself may have afterwards enlarged the depression. It is easy to see that the formation and action of anchor-ice could not be continued very long, as the process is self-destroying; for in proportion as the depression produced became larger and deeper, the quantity of anchor-ice formed would become less, that is, granting the author's own premises; and it seems scarcely probable that a glacier, if it can excavate a lake-basin, should do so at or near its termination, or where it is on the point of melting, its force being there reduced to a minimum.

4. The chief object of the paper "On the Permian Rocks of the North-west of England, and their Extension into Scotland," by Sir R. I. Murchison and Professor Harkness, is to prove that certain masses of red sandstone in the north-west of England belong to the Permian formation and not to the Trias. By this alteration in the classification of these rocks, which is necessarily founded on strati-

graphical considerations, the authors are enabled to show that the Permian strata of the north-west of England consist of three members, namely, the Rothliegende or Lower Permian, the Magnesian Limestone (Zechstein) or Middle Permian, and the sandstones in question forming the Upper Permian; and they bring forward this fact as an argument against the adoption of the new term "Dyas," proposed by Dr. Geitnitz. Whether this particular view of the relations of the Permian Rocks in the north-west of England be right or wrong, we do not see why an old-established name, against which there can be no possible objection that is not frivolous, should be abandoned for a new one, which is very likely not to be appropriate in all cases. The term "Trias" was adopted for two reasons: firstly, because it was proposed by von Alberti, who first clearly showed the relations and connection between the different members of the formation; and, secondly, because it was found to be appropriate. On the same principle, the term Permian, which was proposed by Sir R. I. Murchison, and has answered every purpose for so many years, having been used by every writer on the subject since it was established, may surely be allowed to remain now, when there is no good cause for displacing it; for although Dyas and Trias may sound well together, Geology is not Poetry, that it should reject reason for want of rhyme!

5. The Annual Report of the Council contains this year a *résumé* of the contents of the Society's Museum, in addition to the usual statements respecting the general condition of the Society, which appears to be extremely prosperous. The remarks on the Collections of Specimens of Rocks and Fossils are chiefly utilitarian in character, as they refer more to the value of the collections as materials for study, and to the facilities afforded by the Society for that purpose, than to the absolute scientific worth of the Museum. We very much doubt whether this is the legitimate light in which the matter should be looked at, but to discuss it thoroughly would require us at once to plunge into the depths of that fundamental question—What is the proper object for the Society to keep in view, as the end and aim for which they retain and keep in order a large Collection at a great expense. This matter, though very important to the Society, can scarcely be argued here; but so far as we understand it, it appears to us that the Museum of a learned Society is designed, not so much to instruct the tyro, as to form a storehouse of classical specimens, such as have been specially described in the Society's own publications or elsewhere, as well as those from remote and little known localities, which have never been determined. Of course, specimens for comparison are indispensable, but mere show-specimens and endless varieties of rocks and fossils from all sorts of localities—duplicates in all essential respects —are out of place.

The excellent collection of British Rocks and Fossils at the Museum of Practical Geology renders the Society's British Collection, so incomplete as it is, of comparatively slight value, and it seems a question worthy the consideration of the Council, whether it would not be advisable to re-arrange their British specimens on the same plan as that on which their Foreign Collection is now disposed, rejecting all but type specimens, in which, especially those relating to the early days of the science, the Society is very rich.

These remarks have occurred to us from reading the statement respecting the present unsatisfactory condition of the Collection of British Rocks and Fossils, and contrasting it with the really useful manner, in which, thanks to the late Mr. Horner, their foreign specimens are now arranged.

VII. MICROSCOPY.

(*Including the Proceedings of the Microscopical Society.*)

The immense field of research which is open to the microscopical worker is daily entered upon by fresh labourers. The journals of Natural Science throughout Europe and America teem with new discoveries and new details of knowledge obtained by the use of this instrument. The length of our Chronicles, however, compels us to postpone many interesting facts to a future number, and we must content ourselves chiefly with a brief record of what is passing at home in accordance with the limited space at our disposal.

Professor Allman has recently shown that certain parts of the organisms of the Hydroida consist of Amœbiform protoplasm, and that pseudopodia in every way comparable to the pseudopodia of the Amœbæ are emitted from these masses. The singular bodies known as "nematophores," which are produced as buds at definite spots upon the hydrosoma of the Plumulariadæ, and contain clusters of large thread-cells, appear to consist of a granular protoplasm similar to that composing the Amœbæ. When examined in a trough of sea-water under the microscope, this mass of protoplasm may be seen to slowly elongate itself into variously-shaped processes, exactly like the pseudopodium of an Amœba. This occurs more particularly in *Antennularia antennina.*

Professor H. Karsten has been renewing his researches on the development and structure of the Vegetable Cell. His very lengthy and elaborate paper, containing as it does an interesting notice of original observations on this subject, has been translated in the 'Annals and Magazine of Natural History' for March and April.

The microscope, when applied to investigating the minute anatomy of the smaller forms of insect life, is sure to be productive of new and interesting facts; and it is, indeed, much to be desired that we had more observations of this nature on record. Dr. Leonard Landois has published a very complete monograph of the anatomy of *Ptharius inguinalis*, in which the minutest details of its structure and anatomy have been followed out with great care and highly interesting results. The blood of insects is one of those fluids among the invertebrate animals about which so much remains to be learned. Like the blood of vertebrate animals, it is corpusculated, and contains much mineral matter. The fluids of the Annelida, though hardly comparable to the blood of the insect, also contain corpuscles, the intra-visceral fluid being the most remarkable on this account, whilst the respiratory fluid contained in distinct vessels is in general brightly coloured, and also, though less obviously, contains corpuscles. Dr. H. Landois has devoted considerable attention to the study of the blood of insects. By allowing the liquid to evaporate, he has succeeded in obtaining the various salts of the blood in a crystallized condition, and has been enabled thus to ascertain the nature of the mineral constituents of the blood in many of the commoner forms of Coleoptera and Orthoptera. They are found to differ in various species, as does also the form of the blood corpuscle.

We may notice here a form of microscope made by Mr. Ladd, of Beak Street, and specially adapted for use in museums and public galleries. Two of these instruments have for some time been in use in the Food Museum at South Kensington, and have answered their purpose most satisfactorily. The instrument is an ordinary compound microscope, with a revolving stage capable of receiving a dozen objects at the same time. By turning the disc, the objects are brought in succession under the eye of the observer. The focus is kept fixed, as is also the reflector, so that an inexperienced person cannot disturb the arrangement, which may be made by one of the functionaries of the Museum. If such instruments as these were placed in the galleries of the British Museum and such places of public instruction, supplied with suitable objects, it would add greatly to their general usefulness and interest. Among the various works which have been published during the past quarter, for the purpose of assisting the student in the use of the microscope, is one by Dr. J. W. Griffith, conjoint author of the 'Micrographical Dictionary,' entitled 'An Elementary Text-Book of the Microscope.' The figures, of which there are over four hundred, are very well executed, and contain drawings from among almost every class of objects likely to come under the student's observation. We notice the work fully in another section of this Journal.

The formation of societies intended to unite individuals engaged or interested in studies connected with the microscope must always be hailed with pleasure, as indicating an advance in the progress of Microscopical Science. A Microscopical Society has been formed at the University of Oxford, under the presidency of Dr. Acland, the Regius Professor of Medicine: many distinguished members of the university have joined the Society, and it is to be expected that an impulse will be given thereby to independent research, which cannot but lead to important results.

Microscopical Society of London.

Although the meetings of the Society have been well attended during the past quarter, yet few papers of interest have been communicated. Dr. Greville, who has worked so indefatigably at the group of the Diatomaceæ, continued his series of papers on "New and Rare

Diatoms." Indeed the deposit in the Barbadoes, from which most of his new species are derived, seems to be inexhaustible. Like similar deposits in the island of Mull, in Sweden, and the coast of Africa, the "Barbadoes earth" is composed of little else but the skeletons of these most beautiful and elegant plants. The abundance of species in a single locality is indeed very remarkable, for here is a truly fossil deposit, richer already in some extensive genera than any other known locality, while various genera of singular structure appear to be altogether peculiar to it. Forty-four species were detected some short time since in an examination of the water of the river Thames, as supplied to London by the various water companies, but here we have a variety of species which far exceed that number. The new species described by Dr. Greville belong to the genera, *Eupodiscus*, *Aulacodiscus*, *Auliscus*, *Biddulphia*, *Triceratium*, and *Entogonia*. Microscopists and naturalists generally are much indebted to Dr. Greville for the persevering manner in which he pursues his researches on this subject.

On the 8th of June a most valuable and important paper on "The Structure of the Sarcolemma of the Muscular Fibres of Insects, and on the Exact Relation of the Nerves and Tracheæ to the Contractile Tissue," was communicated by Dr. Lionel S. Beale, F.R.S., physician to King's College Hospital, and Professor of Physiology and General and Morbid Anatomy, in King's College, London. This paper contained new observations by the author relating to the mode of distribution of nerves to voluntary muscles. It is a continuation of his researches upon this subject, published in the 'Philosophical Transactions' for the years 1860, 1862, and 1863, and in the 'Archives of Medicine,' vols. iii. and iv. In the present communication he showed that the air-tubes or tracheæ ramified very finely over every part of the sarcolemma, anastomosing with one another, so as to form a network, the meshes of which were a little wider than the striæ of the muscle. The nerve fibres divided until very delicate ultimate branches, less than $\frac{1}{10000}$th of an inch in diameter, resulted; but each of these consisted of *a great number of individual fibres.* These branches appear to become lost upon the surface of the sarcolemma; but by examining specimens preserved in strong glycerin, and in which the contractile tissue had been ruptured at the moment of death within the tube of the sarcolemma, the bundle of nerve fibres was seen to break up into a plexus of extremely minute fibres, from which branches passed and ramified in the form of a network, or secondary plexus over every part of the sarcolemma. The appearances demonstrated in the author's specimens were utterly incompatible with the notion entertained by certain continental physiologists, that the nerve terminated by *free ends* upon the surface of the sarcolemma, or by blending with this structure; and also with the doctrine that the nerve perforates the sarcolemma and comes into actual contact with the muscular tissue.

The observations were made upon the common maggot or larva of the meat fly with the aid of powers varying from 1,000 to 2,500 linear.

The general conclusion is, that as in vertebrate animals, the nerve forms a network or plexus, which ramifies over every part of the elementary muscular fibre; but the branches do not come into contact with the contractile tissue itself, or with its nuclei in any part.

These observations of Dr. Beale, in connection with his former researches, must serve to establish very important results with regard to the morphology of the nervous system. It seems to be now a definitely established fact that the ultimate fibres of the nervous cords do not end in free extremities, but form a connected network or plexus.

VIII. MINING, MINERALOGY, AND METALLURGY.

Mining.

The rapidity with which our blast furnaces swallow up iron ore naturally gives rise to much anxiety, lest the supply should be unequal to the demand.

Nearly *eight millions of tons of ore* are required to meet the present necessities of manufacture. Eagerly, therefore, are the native stores of iron ore sought out, and this eagerness is rewarded by many new and important discoveries.

At Belsdale, the place probably which was once worked by the Monks of Rivaulx Abbey, a large deposit of iron ore has been discovered. It had been traced in the Howardian Hills, the Derwent Valley, and near Malton. At Oldstead, near Coxwold, and at Keldy Castle, near Pickering, an excellent ore has been opened upon. We are gradually finding the links which form the chain of the vast deposits of ore extending from Whitby, with some brief interruptions due to geological changes, through Lincolnshire, across Northamptonshire and the adjoining counties, to Oxfordshire.

In the Western counties, a similar activity exists, and many new discoveries have been made. We are receiving some considerable importations of iron ore from Norway. This Norwegian ore is of a remarkable character, being, indeed, a titaniferous iron ore, much of it containing 30 per cent. of titanic acid. It is thought that this ore will be of great value in the manufacture of steel, and an English company is formed to work the Norwegian mines.

A series of experiments have been tried in Dolcoath Mine, in Cornwall, on the use of gun-cotton instead of gunpowder, in blasting the rocks. Baron Lenk's gun-cotton, as prepared by Messrs. Prentice and Co., was used, and the results were, on the whole, satisfactory; a larger quantity of rock being displaced with a quantity of gun-cotton less than one-half the weight of gunpowder required. We shall report all further experiments which may be made.

There are no novelties to record in connection with British mining. Nearly all our Mineral industries are, at present, working under the pressure due to the low prices of metal. There has been, and, to a certain extent there still continues, a great deal of unnatural excitement in connection with mining speculations. The result must prove to be, in every way, disastrous for the actual satisfactory exploration of mineral districts. Gambling transactions, and they are nothing more, cannot be associated healthfully with any legitimate industry.

We had hoped the *Mines Commission* would ere this have made their Report to the House of Commons. We are informed that this Report, which is a most voluminous one, will be published during the ensuing month. It is unfortunate that the recommendations it may give, will not have the advantage of that consideration, during this Session of Parliament, which so important a matter, as the health of our mining population, demands. We hope that Lord Kinnaird, or some of the Members of the House of Commons, who are on this Commission, will embrace an early opportunity next Session of procuring some legislative enactments to prevent the recurrence of those conditions which are easily remediable, and which involve the loss of life and the destruction of health amongst the metalliferous miners.

We are pleased to see that Mr. H. Curwen Salmon has commenced a series of papers "On the Mines and Mining Operations of Cornwall."* No man can treat this subject more satisfactorily than Mr. Salmon, some of whose descriptions of our large and important mines have been very valuable contributions to this class of literature. At the Dudley Scientific Art and Industrial Exhibition, there was held a conference on Practical Mining. Mr. Rupert Kettle read on that occasion a paper "On the wasteful methods of working the South Staffordshire coals," and called attention to many sources of loss in connection with the system persevered in by the ground bailiffs of that district. There was some angry feeling manifested; but there is every reason for hoping that much good will result from this conference, and that the South Staffordshire coal proprietors, and the colliers, will have to thank Mr. Kettle for calling attention to their shortcomings.

Mr. Arundel Rogers, Barrister-at-Law, of the Inner Temple, has supplied a want in a very satisfactory manner. Few things are more obscured than the laws relating to Mining and Minerals. Mr. Rogers has endeavoured to give in a clear and comprehensive manner a statement of the laws of mines in England, Ireland, and Scotland.† Every one being connected with mining explorations, would act wisely to possess this work.

Having a remote connection with our subject, we may direct attention to a singular instance which has been brought forward to prove the preservative powers of the waters of old mines. M. Morin exhibited before the Academy of Sciences of Paris a piece of pine-wood, a portion of a wheel which has been found in an ancient mine in Portugal. It is believed to be at least 1,400 years old, and is now in a tolerably complete condition in the *Conservatoire des Arts et Métiers.* This preservation is due without doubt to the influence of solutions of sulphates of iron and of copper in the waters of this abandoned mine.

* 'The Mining and Smelting Magazine: a Monthly Review of Mining, Quarrying, and Metallurgy,' &c. May, 1864. Simpkin & Marshall, London.

† 'The Laws of Mines, Minerals, and Quarries in Great Britain and Ireland; with a Summary of the Laws of Foreign States, and practical directions for obtaining Government Grants to Work Foreign Mines. By Arundell Rogers, Esq. London: Stevens, Sons, & Haynes.

The writer of this notice has in his possession a piece of timber, believed to be oak, which was found in Pontpean mine, Normandy, where it had no doubt lain from the period when the Romans worked the mine. It is intensely black, but as solid as it ever was.

At the "Stream Works" for tin at Carnon and at Pentnam, in Cornwall, seventy feet below the present surface, oak shovels have been discovered which were probably used by the British miners who supplied the Tyrian merchants with tin. Similar implements have been found in the ancient mines of Dartmoor, and in the Roman mines of Cardiganshire. These instances sufficiently prove the preservative powers of the sulphates of the metals.

Mineralogy.

An interesting examination of some minerals of the chlorite group has been made by Mr. John B. Pearse.* The diversities of colour among the varieties of the mineral species are in many cases still unexplained. The Kämmererite from Lancaster county, Penn., for example, is of three kinds, one coloured pure green, a second red and green, while the third is pure red. Mr. Pearse's investigations were to determine the cause of this variation. We cannot transfer to our pages all the results obtained and the discussion on them; these must be sought in the original paper. The chief conclusion is, that "the cause of the difference of colour is unanswered by analysis. It is possibly due to molecular arrangement."

The name of *Grastite* is proposed for the new green variety, and Grastite and Kämmererite may be supposed to be formed thus :—

Grastite—1 atom of kaolin.		Kammererite—1 atom of kaolin.	
2 „	olivine.	3 „	olivine.
5 „	brucite.	1 „	serpentine.
		5 „	brucite.

Mr. T. Sterry Hunt commences in 'Silliman's Journal' his "Contributions to Lithology."† No one has contributed more to the Chemistry of Rock-formations than Mr. Sterry Hunt; we may therefore regard those papers as valuable aids to our knowledge. Referring especially to the formation of granite, and to Mr. Sorby's discovery of fluid cavities in the quartz crystals,—one of the constituents of that rock,—Mr. Sterry Hunt has the following remarks, which from their high interest we think especially deserving of note :—

"The admirable investigations of Sorby on the microscopic structure of crystals, have demonstrated that water has intervened in the crystallization of almost all Plutonic rocks. He has shown that quartz, both of granite and of crystalline schists, contains great numbers of small cavities partially filled with water, or with concentrated aqueous solutions of chlorides, sulphates of potassium, sodium, calcium, magnesium, sometimes with free chlorhydric acid. . . . As these fluid-cavities enclosed the liquid at an elevated temperature, its subsequent cooling has produced a partial

* 'The American Journal of Science and Arts.' (Silliman.) Vol. xxxvii. No. 110, March, 1864.

† 'The American Journal of Science and Arts.' (Silliman.) Vol. xxxvii. No. 110, March, 1864.

vacuum, which is again filled on heating the crystal; so that the temperature of the crystals at the time of their formation may be approximately determined." . . . Mr. Sorby has determined this temperature, and "represents the lowest temperature at which the consolidation could have taken place, which varies from 340° C. to 380° C. in the Vesuvian minerals, and 356° in the quartz of the trachyte of Ponza; to the mean of 216° in the Cornish granites, to 99° in those of the Scottish Highlands, and even descends to 89° in some parts of the granite of Aberdeen. Mr. Sorby has calculated the pressure in feet, of rock, which would be required to compress the liquid so much that it would just fill the cavities at 360°C. The numbers thus obtained will therefore represent the actual pressure, provided the rock was in each case consolidated at that temperature. It would thus appear that the trachyte of Ponza was solidified near the surface, or beneath a pressure of only 4,000 feet of rock; while for the Aberdeen granite the pressure was equal to not less than 78,000 feet, and for the mean of the Highland granites 76,000. The Cornish granites vary from 32,400 to 63,000, and give, as a mean, 50,000 feet of pressure. In this connection Mr. Sorby remarks that, from Mr. Robert Hunt's observations on the mean increase of temperature in the mines of Cornwall, a heat of 360° C. would be attained at a depth of 53,500 feet."

In relation to this subject, the experiments made by Dr. Fairbairn, in Dukinfield Colliery, should be named. In a lecture on "Natural Laws"* recently delivered by that gentleman, the results are thus given. It should be stated that Dukinfield is above 2,100 feet, or upwards of 350 fathoms in depth. "The amount of increase indicated in these experiments is, from 51° to 57° 40′, from 20 to 693 feet below the surface, or 1° in 99 feet; but, if we state the results which are more reliable, namely, those between 693 and 2,055 feet, we have an increase of temperature from 57° 40′ to 75° 30′, or a mean increase of 1° in 76·8 feet. This rate of increase is not widely different from that obtained by other authorities, such as Walfeoden and Arago, who found an increase of 1° in 59 feet. Other experiments have given an increase of 1° in 71 feet." Dr. Fairbairn, with Dr. Joule, made an extensive series of experiments to ascertain at what depth beneath the surface of the earth the rocks would become fluid with this increase of temperature. "If," says Dr. Fairbairn, "we assume the rate of increase to be continued to a depth of nearly 3 miles, we arrive at the temperature of boiling water; at 39 miles we attain an amount of heat equivalent to 3,000°, which would melt the hardest rocks." The experiments to which we have referred were specially to determine if the melting point of bodies was influenced by pressure—the result was, "*an increase in the temperature of fusion proportional to the pressure to which the fused mass was subjected.*" "All these conditions tend to increase the solid thickness of the earth's crust, and we may venture to state that at a depth of 100 miles we should find a pressure equal to 1,200,000 lbs., or nearly 600 tons on the square inch." The ratio of increase in the temperature of fusion being 1° for every 500 lbs. pressure; therefore, taking 2,000° F. as the temperature of fusion at the

* Two Lectures on Iron and its Applications, &c., and on Natural Laws, delivered to the members of the Literary and Philosophical Society, Newcastle-on-Tyne, by William Fairbairn, C.E., LL.D., F.R.S., F.G.S.

surface of the earth, a temperature of 4,600° would be required at the depth of 100 miles. "Reasoning from these facts, we came to the conclusion that the earth's nucleus, under the enormous pressure to which it is subjected, may not be fluid but solid, or probably in a semi-fluid state."

In the Swiney Lectures on Geology, recently delivered by Dr. Percy in the Theatre of the Royal School of Mines,* the lecturer states, that there are many difficulties which have always stood in the way of receiving the hypothesis that granite is an igneous rock, "difficulties" known, at all events, to those who have been accustomed to make experiments on the fusion of minerals at high temperatures. This is especially seen by examining the condition of quartz; it is always found in the crystalline condition, and has invariably a specific gravity of 2·6. There is not a single instance known to the contrary. Hence there is reason to believe that the quartz never could have been fused, for the moment silica is fused, no matter in what condition it was previously, a peculiar glass-like colloidal mass is produced, having a specific gravity, which never exceeds 2·3. Therefore, there is good reason to conclude that granite could never have been formed under the condition of a high temperature.

Rammelsberg has recently presented to the Physico-Mathematical class of the Berlin Academy of Sciences a memoir upon the combinations of the oxide of lead and titanic acid which are found native.

Some very fine examples of the mineral vanadinite had been obtained from Windiskappel, in Carinthia.

We find an extensive examination of the vanadium minerals has been made by Czudnowicz.† He shows that the determination of vanadic acid in the *rhombic vanadinite* from Carinthia is incorrect, and the conclusions that the mineral was a simple vanadate of lead is not justified. His analyses show it to be a ter-basic vanadate of lead and zinc.‡

In the granite of the Island of Elba, associated with beryl, tourmaline, and quartz, two substances were found long since, to which the names of *Castor* and *Pollux* were given. These minerals were described by Breithaupt, and subsequently examined by Plattner. On the authority of this analysis Gmelin says, "Pollux appears to contain a larger quantity of alkali than any other known silicate mineral." It has now been more closely examined by M. Felix Pisani, and the results obtained by this chemist have been communicated by Henri Sainte Claire Deville to the Academy of Sciences of Paris. The analyses of Plattner and Pisani agree very nearly as far as the silica and alumina are concerned. In place, however, of the potash and

* These lectures have been most satisfactorily reported in the 'Chemical News.'

† 'Poggendorff's Annalen,' vol. cxx.

‡ 'Revue Universelle des Mines, de la Métallurgie, des Travaux Publics, des Sciences et des Arts—appliqués à l'Industrie,' sous la direction de M. Ch. de Cuyper. This journal contains several valuable papers on mineralogy, metallurgy, and mining, with notices of the allied science geology, and of the applications of science to manufacture. We shall, from time to time, avail ourselves of the useful matter which this journal may communicate.

soda of the former, M. Pisani has given *oxide of cæsium*, which metal was mistaken for the alkalies by Plattner. This is the first mineral discovered with a known base of the new metal cæsium.

M. Pisani has also discovered cæsium in the rose lepidolithe or lithia mica of Elba, and with it a considerable quantity of the metal rubidium.*

Sources from which the new metal *thallium*—which was discovered by Mr. Crookes—may be obtained, are increasing upon us. Mr. Emerson Reynolds informs the *Royal Geological Society of Ireland* of the existence of a thalliferous pyrites in Ballydehob, county Cork; and M. Schrotter announces to the *Imperial Academy of Sciences of Vienna* the presence of this metal in the *lepidolithe* of Moravia (a lithia mica) and in the *mica* of Linnwald, Bohemia.

'A Popular and Practical Exposition of the Minerals and Geology of Canada' has † been published by Professor Chapman. This volume gives a popular, yet full sketch of the Mineralogy and Geology of Canada.

Mr. N. S. Maskelyne communicates ‡ the discovery of a new mineral from Cornwall, "prismatic, in crystalline form, and consisting probably of a basic sulphate of copper, insoluble in water. It occurs in minute but brilliant crystals, and in fine masses of the richest blue colour; it forms a thick incrustation upon a tender killas."

The phenomenon of asterism in natural crystals will be familiar to most persons; it is not so generally known that this may be produced artificially. Rose showed long since that the star of mica could be produced upon isinglass by impressing the mica on it. G. A. Grüel § gives a very simple method for producing asterism; a piece of glass is cut into a triangular figure, and then rubbed backwards and forwards a few times on a sheet of fine emery paper, each of the three sides being successively guided against a metal rule, which, at the same time being pressed on the emery paper, keeps it in position.

We have found that we may obtain glasses exhibiting any number of radial lines by fixing the glass on a lathe. The lathe enables us to produce a figure with any number of sides, and the application of the emery paper or a fine file, parallel to each side, is carried out without difficulty.

A lignite of superior quality is said to have been discovered in the Punjaub. This discovery has been made about 150 miles north of Lahore, upon the borders of Jhelum, a little to the west of the road to Peshawur, nearly on the line of the railway projected by Mr. Andrews from Lahore to Peshawur. It has been analysed for the Railway Company, and it is said to be for use in locomotive engines superior to the coal found in Bengal. This lignite is therefore necessarily exciting considerable interest, for if it exists in large quantity, which is said to be the case, it will materially facilitate the extension of the railway system in the Punjaub.

* L'Institut, and Les Mondes.

† By E. J. Chapman, Ph.D., Prof. University College, Toronto. Toronto, 1864.

‡ 'Philosophical Magazine,' No. 182, April, 1864.

§ 'Poggendorff's Annalen,' vol. cxvii. p. 635.

Metallurgy.

Various attemps have from time to time been made to obtain malleable iron or steel directly from the blast furnace. A few only of these experiments can be regarded as having been successful. At the present time arrangements on a very large scale are being made in immediate connection with the Barrow Hematite Iron Works of Messrs. Schneider and Hannay, to receive the cast-iron directly from the blast furnaces into the "converters" of the Bessemer process, and thus produce steel without allowing the melted mass to cool. On the Continent this is adopted in many of the larger iron-producing establishments, and we hear of several works about to be erected in this country, by which, without doubt, steel will be produced at a cost but a little exceeding that of cast-iron.

M. Lamy has been carefully studying the conditions of iron produced in the blast furnace. He notices a loss sustained from the cast-iron meeting with an oxidizing heat and atmosphere in the hearth, causing part of it to pass into slag. Again, in refining, the iron is fused under an oxidizing flame, by which about 10% is scorified. In puddling, the process is carried on in an oxidizing atmosphere with a further loss. M. Lamy estimates the total loss in converting pig-iron into wrought-iron as not less than from 15% to 20%. He therefore proposes to combine the three operations in one, or rather, as we understand it, to carry out the three operations consecutively in the same furnace. The apparatus proposed consists of two distinct parts; one placed above the other. The upper furnace is the blast furnace in which the iron is smelted from its ores; this part differs from the ordinary blast furnace in the body and boshes being formed of distinct truncated cones—connected by their bases—but separated from each other by an opening, which the inventor calls the *pyrote.* The twyers are in the upper part of the boshes, and the blast is directed downwards. The hearth is formed of a slightly inclined plane, which leads to the lower apparatus. This is essentially a turbine of wrought-iron attached to, and moved by, an axle protected by solid masonry; this works on a platform furnished with several ranges of perpendicular knives, which are for dividing the metal driven out by the centrifugal force of the turbine. On each side are two fireplaces, arranged so as not to give off oxidizing gases.

When the furnace is charged, the blast is turned on by the upper twyers, and thus a high temperature is produced in the boshes. The oxidizing atmosphere is changed into a reducing one by the conversion of the carbonic oxide into carbonic acid. The iron ores, therefore, in descending, only meet with reducing gases, and the product perfectly liquified flows along the inclined plane to the crucible, and may, if the object is to get cast-iron, be tapped in the usual manner. When wrought-iron is to be made, the melted cast-iron is directed on the centre of the turbine, which is in motion, and air and superheated steam are turned through twyers fixed at the lower part of the furnace.

The cast-iron is divided by the centrifugal motion, and is brought into contact with an oxidizing atmosphere, the air acts on the carbon and silicon, and, it is said, the stream on the phosphorus and sulphur, so that refined iron is produced very rapidly.

In the third stage of the process, the carbon of the cast-iron acts on the bed, which is composed of rich slags and sheets of wrought-iron, and after "rabbling," the puddled ball is ready for shingling. When it is required to make steel, the coverings of the sole (rich slags, &c.) are omitted—the rotation of the turbine is accelerated, and the blast in the twyers increased.

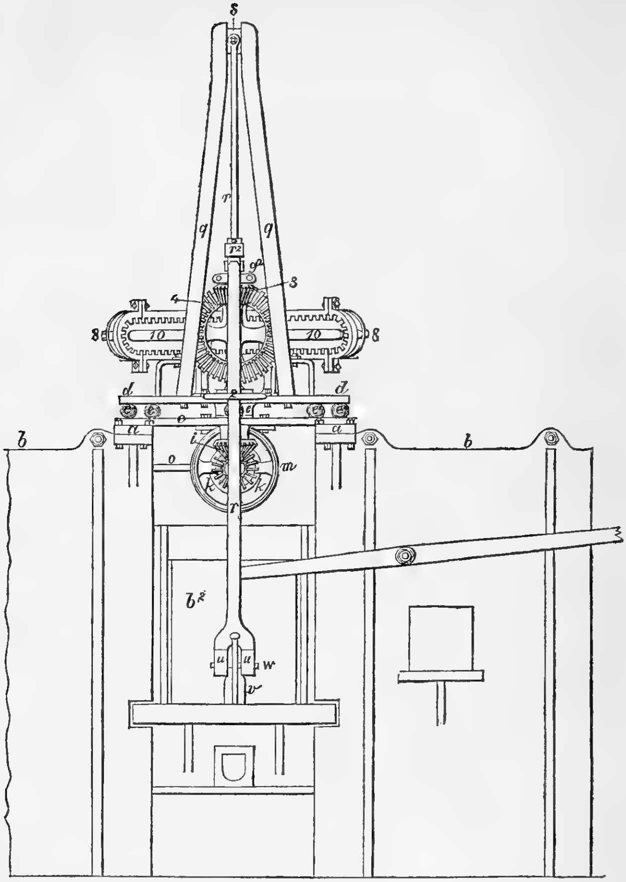
We are not aware of any experiments, on a large scale, having been tried, except by M. Lamy himself, but there is so much ingenuity in the arrangements, and each stage of the process has been so carefully studied that, except there are mechanical difficulties in the way, it appears to promise a successful issue, and much economy.

The most severe labour to which man is subjected is, that of puddling iron—the process by which pig-iron is converted into malleable iron. The "puddler" has to manipulate balls of iron, weighing from 2 cwt. to 3 cwt., in front of an intensely heated reverberatory furnace. Many schemes have been devised for performing this operation by machinery, but hitherto it does not appear that any of them have been successful. In 1861 a patent was secured by Mr. W. H. Tooth. Dr. Percy, in his "Metallurgy," notices the fact, but he gives no indication of the character of the machinery employed, or of the results of its application. It may, therefore, be concluded that it did not answer the desired end. Mr. James Nasmyth sought to facilitate the process of puddling, by the introduction of steam "to mechanically agitate the molton iron, and thereby keep exposing fresh surfaces of the iron to the oxygen of the iron contained in the atmosphere passing through the furnace." This process has not, as far as we know, been successfully applied in any of our iron works.

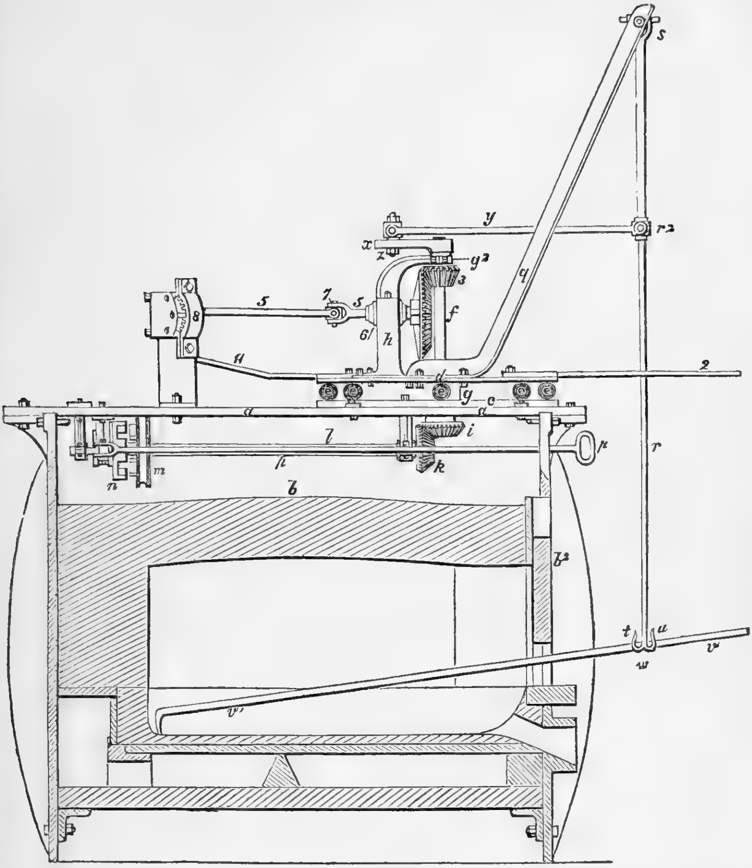
The latest attempt to apply machinery for puddling iron is, that of Mr. John Griffiths. This application is more promising than any which have preceded it, and is now, we are told, on trial in several works.

The puddling process consists in stirring the melted cast-iron on the bed of a reverberatory furnace, so as to expose it to the action of the air. This is usually performed by means of a stirring tool, called a rabble, by which the workman stirs the melted iron. Mr. Griffiths, by means of machinery, gives nearly the same motion to a rabble as is given to it by the puddler, and the puddling is effected without manual labour, or nearly so.

The construction of the machinery will be easily understood by reference to the accompanying woodcuts (pages 494 and 495). *a a* are two cross bars fixed on the furnace *b*, on which rests a circular bed-plate *c*, above which is another circular plate *d*, which has a reciprocatory motion through about a quadrant. This upper plate *d* is supported on the bed-plate *c*, by spheres or balls *e*, which move in a groove. A vertical shaft *f*, working in the bearing *g*, in the bed-plate, passes through and works loosely in the movable plate *d*. This shaft below the bed-plate *c* carries a bevil-toothed wheel *i*, which gears with another bevil-toothed wheel *k*, on the horizontal shaft *l*,



from which the several motions of the machine are derived. Rotary motion is communicated to this shaft by a chain or band from a prime mover, passing over the loose clutch pulley *m*, near which is a fixed clutch *n*, capable of sliding on a feather on the shaft, and by means of the forked lever *o*, and rod *p*, it can be thrown into and out of gear with *m*, and motion communicated to the horizontal shaft, or arrested. To the movable plate *d* is fixed a jib *g*, which projects 18 inches beyond the furnace door, to this by a socket-joint *s*, is suspended a hanger *r*, which moves both longitudinally and transversily. The lower end of this hanger is made into two forks *t*, *u*, one on each side, into one or other of which forks the puddling tool or "rabble" *v*, can be jointed by the axis *w*. This description, with the woodcuts, will enable the reader to understand the principle of this invention, the object of which is to impart to the puddling tool a backward and for-



ward motion in combination with a reciprocatory motion of partial rotation. It would be tedious to describe minutely those parts, through the agency of which these motions are obtained. To the mechanic those parts of the machine marked with numerals from 1 to 11, will sufficiently explain themselves, and to those who are not familiar with the detail of gearing machinery, a brief description would not be intelligible. The end to be attained in a machine for puddling is to communicate to the "rabble," or puddling tool, every motion which can be given to it by a man. Mr. Griffiths has certainly devised a machine which gives most of them. It will be understood that by the combined motions the puddling tool is made to travel up and down, and across the furnace. The main question is, whether this or any other machine can substitute those motions which are dependent upon the trained skill of an experienced puddler, and on which depends the production of good or bad iron.

In order to facilitate the process of oxidation, and to refine the iron, Mr. Griffiths substitutes, at the proper times during the process, a *hollow* rabble, or puddling tool. The object of this being to convey air, either hot or cold, to the iron, this blast being supplied to the hollow tool by a flexible tube capable of ready attachment to, and detachment from, the tool.

In the *Annales des Mines* in 1862,* MM. Dumeny and Lemut described a mechanical puddler which had been adopted at the Clos-Mortier Forges, Haute Marne. Even then the inventors conceived they had obtained an improvement in the quality of the products, an economy in the consumption of materials, and a diminution in the labour of the puddler. In a recent number † of the same journal, M. Lemut informs us that the result of working at seven furnaces fitted with the mechanical puddler is so satisfactory, that there is no hesitation felt in applying them without further modification to all the other furnaces. In the present state of things in this country, it is very important to obtain the advantage of the experience of two years' practice in large and well-conducted forges. M. Lemut gives the following summary :—

The consumption of fuel for each ton of malleable iron made is considerably reduced.

Economy is effected in the general expenses, as the work is accelerated, and the production of each furnace increased.

The "underhand" is dispensed with, and the labour of the puddler is diminished.

But, he says, the improvement in the quality of the iron is the most important result of mechanical puddling. Grey pig-iron made with coke, which was difficult to refine under the action of three or four heavy rabbles, "came to nature" in a very short time with the addition of cinders, and produced iron of a superior quality.

It may be incidentally noticed that, on the Continent, considerable attention has lately been given to the construction of the blast furnace. In 1859, Mr. Alger, an American ironmaster, formed a company for introducing a new form of furnace, the hearth being an elongated ellipse. Although some experiments made appeared to indicate a favourable result, this furnace has not been, in this country, adopted. A Russian mining engineer, General Wladimir Rachette, showed at our Exhibition of 1862, a model of his new blast furnace. This did not excite much attention in this country, but in Russia and in Germany some of Rachette's furnaces have been constructed, and the results are said to be in every way satisfactory. Like Alger's furnace, Rachette's has a hearth of a narrow and elongated section. A good account of this furnace and its applications has been given by Dr. L. Beck, of the Metallurgical Laboratory, Royal School of Mines.‡

M. Eugène Peligot has recently brought before the Academy of Sciences, of Paris, the result of his experimental researches on the alloys of zinc and silver, and of silver and copper. These examina-

* 'Annales des Mines,' 6th series, tome ii. 1862.
† 'Annales des Mines,' 6th series, tome iv. 1864.
‡ 'Mining and Smelting Magazine,' April, 1864.

tions have been made with a view to some alterations in the French coinage system. An alloy prepared with 835 parts of silver, 93 parts of copper, and 72 of zinc, presents many advantages. The fact that this alloy is obtained by adding 77 grammes of zinc to each kilogramme of the existing money, is considered a strong recommendation. All the alloys of silver with zinc are found to be perfectly homogeneous, and for coining possesses all the advantages which belong to the alloys of silver and copper, giving a metal, at the same time, of a fine white colour.

An alloy of 850 parts of silver, with 150 parts of zinc, is said, from its fine colour, to be well fitted for bijouterie.*

IX. PHYSICS.

Light.—Since our last Chronicles of the progress of optical science, many interesting researches have been made, foremost of which should be mentioned the striking discovery by MM. Plucker and Hittorf, that certain bodies, such as nitrogen and sulphur, give two very different spectra, according to the temperature to which the incandescent vapour is submitted. To show this, they pass through the tubes (containing the gas or vapour in a highly rarefied state) the ordinary current of an induction coil; in this manner they obtain what is named the *first* spectrum, formed of large bands more or less regular, and often presenting the appearance of channelled spaces cut out by black rays. This corresponds to the lowest temperature. By interposing a Leyden jar, and varying the surface of this jar, the calorific action is likewise varied; in this manner, by gradually raising the temperature of the gaseous body, they find that at a certain point an essential modification takes place in its molecular constitution, and another and entirely different spectrum suddenly takes the place of the former one. This *second* spectrum, corresponding to the higher temperature, is generally characterized by brilliant rays on a more or less luminous ground. Sulphur shows in a striking manner the abrupt passage from one spectrum to the other. Upon gradually increasing the temperature, the first spectrum gets brighter and brighter; when at the moment it attains its maximum of brilliancy, it suddenly disappears and gives place to the second spectrum, the richest in brilliant rays which the authors had ever seen. On lowering the temperature, the second spectrum disappears equally suddenly and gives place to the first.

Nitrogen gives *three* spectra, showing three different molecular conditions. Naming these according to the general character of the bands they show, MM. Plucker and Hittorf consider that nitrogen has two distinct *first* spectra,—one of a yellow colour, corresponding to the less degree of incandescence, and the other of a blue colour, corre-

* 'Les Mondes, Revue Hebdomadaire des Sciences,' tome iv. 15 livraison. 'L'Institut, Journal Universel des Sciences.'

sponding to a higher degree of incandescence. The *second* spectrum is produced by a very much more intense heat than that required to show the two *first* spectra. Oxygen, chlorine, bromine, and iodine have only one spectrum.

Mitscherlich has found that when a drop of a solution of chloride of barium mixed with sal ammoniac is introduced into the flame of a spectroscope, two brilliant green rays, having no connection with the barium spectrum, make their appearance. Sometimes these two green rays are unaccompanied by the barium spectrum, and sometimes they are superimposed upon it. He also finds that most metallic spectra are modified by the presence of hydrochloric acid, or chloride of ammonium vapour; in some the lines entirely disappear, while in others new lines make their appearance. He explains this by assuming that in the one case the spectrum is that of the metal itself, whilst in the other it is that of the compound.

The spectrum of carbon has attracted considerable attention lately. From an examination of the spectra produced by carbonic oxide, carbonic acid, sulphide of carbon, cyanogen, and olefiant gas, either ignited in the air or rendered incandescent by the spark of an induction coil, Dr. Attfield was led to the conclusion that certain lines which were common to all of these compounds were due to carbon, and constituted the spectrum of this element. M. Morren, in examining a candle flame, finds that the blue portion at the base of the flame "is the vapour of carbon preserved from combustion, but kept at a very high temperature by the envelope of hydrogen." M. Morren leaves us in the dark as to how the carbon gets into this vaporous state, neither does he explain how it is that the low temperature of the blue part of the candle flame is hot enough to keep free carbon in a state of vapour, when it is notorious that the highest artificial heat yet produced is insufficient to effect this. According to Dr. Roscoe, the spectra which these various forms of carbon compounds give when in the state of incandescent gas are not quite identical. Thus, the so-called carbon rays obtained with the flame of olefiant gas differ from those obtained by the electric discharge through a vacuum of the same gas; whilst a spark passing through a cyanogen vacuum produces a spectrum identical with that of the olefiant gas flame, and the spark through a carbonic oxide vacuum gives a spectrum coincident with that of the olefiant gas vacuum.

A series of experiments on the intensity of the solar radiation has been made by Father Secchi; his apparatus consists of two cylinders placed one within the other, the space between the two being filled with water at a certain temperature. The aperture of the inner cylinder is closed at one end by a plate of glass, and the other is partially closed by a diaphragm with an aperture; a black bulb thermometer is placed in the axis of the inner cylinder. On exposing this instrument to the sun, it was found that the same difference of temperature between the black bulb thermometer was always maintained, whatever was the temperature of the water, and that the sun at mid-day produced no greater difference between these two temperatures in summer than in winter, although in the latter case the rays have to travel through about twice as much atmosphere. The explanation of this is, that there is more aqueous vapour in the air in summer than in winter, thus fully bearing out the observations of Professor Tyndall as to the power of the vapour of water to intercept the sun's rays.

A discussion has been going on between MM. Van Monkhoven and Bertsch on the possibility of constructing a system of lenses which will augment the intensity of the solar rays without changing their parallelism. M. Bertsch has proposed an arrangement intended to effect this object, consisting of a convex lens, on which the solar rays fall, forming an image of the sun in its focus. Between the lens and focus, however, a small concave lens is interposed, in such a position that the convergent rays, after passing through the second lens, emerge parallel and concentrated. A similar effect may be obtained by having a small convex lens of short focus placed beyond the focus of the larger lens. M. Van Monkhoven argues that although an apparatus of this kind would be applicable to light issuing from a luminous point at an infinite distance off, the instrument is inapplicable to sun-light, because this body has a sensible diameter; and since the image formed at the focus of the larger lens would be necessarily of greater diameter than that formed by the other at its focus, no condensation can possibly take place. To this argument M. Bertsch replies, that he has made the instrument, and it does answer; and that as the angles of the pencils of rays proceeding from the sun never exceed half a degree, they are so small that they may be neglected.

We have already * called attention to some researches by M. G. Quincke, on the optical properties of the metals, in which he showed that their refractive indices were less than unity; in a second memoir by the same author on this subject, the theory is followed out mathematically as well as experimentally, and the further discovery is announced that the refractive index of the metals is dependent upon the angle of incidence and increases with an increasing angle.

When a luminous body is viewed through some kinds of transparent minerals, such as certain varieties of mica, rays of light are seen to diverge from the luminous centre, at equal distances apart. This appearance has received the name of *asterism*. A method of producing asterism artificially, in a manner as clear and perfect as is met with in some of the naturally-occurring minerals, has lately been published by M. C. A. Grüel,† of Berlin. A clear piece of plate-glass is cut in the form of an equilateral triangle, with sides measuring 1½ to 2 inches. The surface of this triangle is then rubbed backwards and forwards a few times on a sheet of fine emery-paper; each of the three sides being successively guided against a metal rule, which at the same time being pressed on the emery-paper, keeps it in position.

* 'Quarterly Journal of Science,' vol. i. p. 342.
† 'Phil. Mag,' series iv. vol. xxvii. p. 400.

The feeble striping of the glass surface thus obtained produces accurately the condition of a series of lines crossing at an angle of 60°, which is fulfilled by the similarly directed edges of the groups of microscopic crystals observed in some kinds of mica, &c. By cutting the glass to the shape of any other regular sided figure, and rubbing it with emery-paper in directions parallel to the different sides, an eight-, ten-, or multi-fold star will be produced, according to the angle under which the series of lines cross. These are best observed by holding the glass near the eye, and looking at a fine hole in a plate of metal behind which a candle-flame is placed.

A new analysis of Fraünhofer's line **D** has lately been communicated to the Royal Society by Mr. Gassiot. The spectroscope with which it was performed was made by Browning, and is, without doubt, the most magnificent instrument of the kind which has ever left the workshops of that optician. The train consists of no less than eleven bisulphide of carbon prisms, the sides of which are prepared by Professor Cooke's method, so as to remedy the curvature of the glass-plate from the hardening of the glue. On examining the double line **D**, after passing through this train, it was found that its two components were separated 3′6″, and that there was a third line exactly equidistant between them, together with other lines, filling up the intermediate space. But the most remarkable circumstance was, that the two dark lines composing the double line, were themselves each split up into three lines, the centre one being the thickest. It is intended to examine other parts of the spectrum with this apparatus, and there is no doubt that very valuable results will be obtained from such an extended investigation.

Spectrum analysis is not only applicable to the detection of metallic elements. By a slight modification of the apparatus, this powerful agent may be applied to the discrimination of a vast number of organic bodies; hitherto, however, this branch of the subject seems to have been unaccountably neglected, Professor Stokes being almost the only person who has assiduously devoted himself to the subject. One of the most recent results at which he has arrived is likely to be of considerable practical importance. He has submitted blood to searching spectrum analysis, both before and after treatment with different chemical re-agents. This liquid exhibits two well-marked dark bands in the yellow and green. These were first noticed by Hoppe, and are eminently characteristic of blood. The addition of an alkaline solution of copper to this fluid still shows these characteristic bands, although to the eye the colour is quite changed. On adding, on the other hand, acetic acid to a solution of blood, the colour was very slightly changed, but the bands had entirely disappeared. A comparison of these bands with those given by some iron salts, negative the supposition that the colour of blood is due to a salt of iron, as such, even had we no other means of deciding.

In a note by M. Marignac, on silico-tungstic acid, he describes a remarkable series of compounds, most of their properties, however, belonging more to the domain of chemistry than optics; one compound, the silico-tungstate of soda, is likely to be of great use in the manufacture of fluid prisms, inasmuch as a solution can be obtained having the specific gravity of 3·05, and being very fluid, but on which glass, quartz, and most stones will float. If its refracting powers are equal to its density, this solution will be invaluable for fluid prisms. We may also mention that a compound of thallium with the elements of alcohol, ethylate of thallium, has also been proposed for the construction of fluid prisms. It is a heavy, oily liquid, of about the density and refracting power of bisulphide of carbon, but unlike the latter liquid, non-volatile.

A most ingenious application of scientific principles to the illumination of theatres has just been carried out by M. Soubra. The footlights in front of the stage of a theatre are almost invariably argand burners, surrounded by glass; not only is there very great danger of the thin dresses worn by the actresses taking fire, but the products of combustion vitiate the atmosphere of the stage, whilst the heated air rising from them just across the line of sight of the spectators in the stalls, renders the view from these seats less pleasant than it would otherwise be. The reason why the flame of an argand burner, or any any other light, points upwards, is owing to the heated air and products of combustion being lighter than cold air; the former, therefore, rise upwards, and cause the flame to rise also. If, however, a downward movement could be impressed upon the heated products of combustion, the flame would equally well follow the same direction, and would continue to burn downwards. M. Soubra, therefore, takes a wide glass pipe, bent in the form of the letter **U**; one leg, however, being considerably longer than the other one. Just inside the shorter leg of the two, an argand burner is inverted, and the longer leg of the tube being heated for a short time, so as to rarefy the air in it, and cause a downward current in the short end, the argand burner is lighted, and the flame, following the direction of the current of air with which it is surrounded, continues to burn upside down—the current once established being sustained by the heat from the inverted flame. The advantages from this new arrangement are as follows:—The supports of the globes, or lamp-glasses, are placed above the flame, and do not intercept the light; the reflectors also are in no danger of becoming blackened by smoke, and they collect rays that would otherwise be lost in the air; the flame has a more elevated temperature, on account of the heat being concentrated by the syphon, and the carbon is consequently rendered more incandescent; the products of combustion may easily be carried away through the longer leg of the tube into a chimney, instead of vitiating the air of the apartments. The advantages as to safety, &c., of this plan are so obvious, that no time should be lost in introducing this method of illumination in this country. It is, we understand, already adopted in France with great success.

Many years ago Mr. Fox Talbot discovered that when a continuous spectrum is examined by covering one-half of the pupil of the eye with a thin transparent plate, so as to modify that part of the pencil of rays on the side of the violet part of the spectrum, a number of transverse bands, alternately light and dark, appear to traverse it. Brewster discovered that these bands were not formed when the thin plate was placed on the side of the spectrum corresponding with the red rays. It has since been discovered that these bands may be produced by interposing the thin plate in other portions of the path of the ray, besides putting it close to the eye. Baden Powell, and Stokes have since studied the phenomena both experimentally and theoretically, and the latter physicist found that the effects were best produced by the partial immersion of a transparent plate in the liquid of a fluid prism. M. Bernard has lately studied these phenomena, and has arranged his apparatus in the following manner:—A ray of solar light passing through a narrow orifice falls on the slit of a spectroscope, the defringent plate being then placed between the aperture admitting the light and the slit of the spectroscope, and some adjustments and arrangements are made, into the detail of which we need not enter. In this manner M. Bernard is enabled to obtain a very luminous spectrum, and he has been led by an examination of the phenomena to the discovery, that through them he is enabled to obtain the length of the waves of any desired ray of light or spectrum line with much greater accuracy than by the ordinary diffraction method. In his memoir he has given the wave lengths of the seven principal rays of the solar spectrum, together with that of the ray **A**, which, owing to its faintness, has not yet been satisfactorily determined, and the green ray of thallium. Their values, expressed in millionths of a millimetre, are—

A = 760·6
Tl = 535·2 *

The diffringent plate of quartz is about a millimetre thick, and its thickness can be determined with absolute accuracy with the spherometer; and when it is remembered that between **A** and **H** there are for this thickness more than 700 interference bands, and that it is easy to estimate to the tenth of a band, it is seen that there are more than 7,000 invariable points in this portion of the solar spectrum, and it is by reference to these that M. Bernard proposes to classify the rays of the alkaline metals and other interesting spectra. For this purpose he has constructed an apparatus which acts both as a spectroscope and a goniometer, and which enables the observer to measure to within 10″, the indices, a knowledge of which is necessary to calculate the wave lengths.

Heat.—Some important results have been communicated to the Berlin Academy by M. Hagen,† respecting the heat of the sun's rays. He has come to the conclusion that the heating effect produced by the sun's rays on entering this atmosphere may be expressed by say-

* Dr. J. Müller ('Quarterly Journal of Science,' vol. i. p. 157) finds the length of the wave of the green thallium line to be 534·8 millionths of a millimetre.
† 'Phil. Mag.,' ser. iv. vol. xxvii. p. 478.

ing that a bundle of rays having a section of a square inch, would in one minute raise the temperature of a cubic inch of water by 0·733 of a degree centigrade. On comparing these results with those of Pouillet, it is seen that the latter observer found the heat of the sun's rays to be one-eighth less. Pouillet, however, assumed that the height of the earth's atmosphere was equal to the 80th part of the earth's radius, whilst M. Hagen finds that the height of the atmosphere, assuming that the layers of air have the same power of absorption, is only equal to the 173rd part of the earth's radius.

In his remarkable work on heat considered as a mode of motion, Dr. Tyndall observed that it would be interesting to see whether the balls of rifled guns would not show signs of fusion. M. Schrœder remarks, that, by having a ball constructed of zinc, he thinks it would be possible to estimate the amount of heat given out on striking the target. He finds that at a temperature above boiling water zinc becomes granular, and that if the heat is very gradually increased, the metal will, without losing its form, assume exactly the appearance of zinc that has been melted. It is not unlikely that an experiment with this metal might furnish some information, but the determinations of temperature would not be very accurate, and it would probably be possible to discover a more certain way of estimating the heat given out by the concussion; at the same time the suggestion is useful in the absence of a better measure of temperature under the conditions of the experiment.

Dr. Tyndall has been for some time past engaged in some investigations on the non-luminous heat-rays of the spectrum with reference to their deportment towards certain bodies which are perfectly opaque to light. He has found that a solution of iodine in bisulphide of carbon entirely intercepts the light of the most brilliant flames, whilst to the ultra red rays of the spectrum the same solution is perfectly diathermic. If a hollow prism is filled with this opaque liquid and placed in the path of the beam from an electric lamp, the light-spectrum will be completely intercepted, whilst the heat-spectrum passes through, and can be examined by a thermo-electric pile. A liquid of this kind, which will allow physicists to sift the heat-rays from the light-rays, will be of great value in many experiments in physical optics. Indeed, the discoverer is not the person to allow such a valuable adjunct to experiment to remain idle in his hands.

It has long been known that heat weakens or destroys the magnetic force in permanent magnets, but we are not aware that any very accurate researches have been made on this subject. M. Mauritius has lately published* some results, in which he shows that when a permanent magnet is alternately exposed to the temperatures 100° C. and 0° C., the magnetism ultimately becomes sensibly constant on the return of the same temperature. It is now found that when the magnetism at 0° and then the magnetism at 100° are measured, a diminution takes place at the higher temperature and a corresponding

* 'Bibliothèque Universelle de Genève,' March, 1864.

increase at the lower temperature, and that the diminution of the magnetic force from 0° to 100° is proportional to its magnetism at 0°. With regard to temporary magnetism induced in soft iron, cast-iron, and steel bars by means of an electro-magnetic coil, it was found that at a bright red heat none of the bars were magnetic. Approximate determinations of the descending temperature at which magnetism begins to be manifested gave 1,000°. With the steel bar the increase of magnetic power takes place at first very rapidly, then for a certain time it goes on slowly, and then again follows a period of rapid augmentation. With the cast-iron bars the second period of rapid increase is also observed, but in a less marked degree; but with the wrought-iron it does not exist. The author believes he may conclude from his experiments that the magnetic properties of iron are developed suddenly at a determinate temperature.

Electricity.—A very valuable instrument for the production of a constant stream of electricity has been for some months past exhibited in the scientific circles of London. It is an electro-magnetic induction machine, but unlike ordinary machines of this kind the stream is constant in one direction, and it can be produced of any tension or quantity that may be required. Many attempts have been made to use induced electricity for telegraphy, but they have generally failed because the tension of the current is too great, and the electricity is in impulses. What has long been wanted is as near an approach to a battery current as possible, and of any required tension or quantity without multiplying the number of battery cells used. The machine must also be perfectly self-acting. The way in which these desiderata are effected in the machine now alluded to is by using two series of induction coils, which are so arranged that one is being magnetized nearly at the same time that the magnetism is subsiding in the other, so that the two induced impulses may be said to overlap each other; and though these are in opposite directions, the spools are so arranged that in the general induction circuit they flow in the same direction, thus making a compound impulse of longer duration, composed of the two opposite inductions. Such a compound impulse is produced from each induction coil, and by an ingenious arrangement of the commutator, they are all turned into one direction, producing a slightly undulating but continuous flow. The machine is made for quantity, the inner coils being of number 12 wire, and the outer of number 18. To an electrician the very name induction coil speaks danger, as it conjures up visions of powerful sparks, many inches long, darting from pole to pole, and capable of piercing through considerable thicknesses of gutta-percha, or even glass. Experiments have, however, shown that such fears are groundless with an instrument of this construction; the two wires may be brought so close together that a considerable magnifying power is required to show that there is any space at all between them, before a spark will bridge across the interval, and it is then of the feeblest and most innocent description, being unaccompanied with noise and scarcely visible in daylight. The striking distance is less than the thousandth of an inch.

Whilst the electrical relations of metals, &c., in aqueous solutions of acids, alkalies, and salts, have been repeatedly, and we may almost say exhaustively examined, few, if any, experiments have been made on the similar relations in fused substances. This gap has now been filled up by Mr. Gore,* who has examined the electrical relations of carbon, magnesium, aluminium, silicium, zinc, tin, lead, iron, nickel, copper, silver, gold, and platinum, in sixty-seven salts or mixtures of salts kept in a state of fusion, in small porcelain crucibles, either by an ordinary Bunsen burner, or when difficultly fusible, by one of his small gas furnaces already described in this Journal. The results are carefully tabulated, and amongst others it is found that the most negative substances in fused salts are generally platinum, gold, carbon, and silver; the most positive substances are generally magnesium, aluminium, and zinc. Silicium is generally electro-positive to carbon, and is strongly positive, and quickly corroded in fused alkalies, alkaline carbonates or fluorides. Carbon is not generally very positive to iron. This investigation throws some light upon the desirable object of obtaining a cheap source of electricity by the combustion of coke or gas carbon. The discovery of some suitable fused salt or mixture, in which carbon is highly electro-positive at a high temperature to iron, nickel, or other infusible and suitable conductor would probably prove a cheap and powerful source of electricity: cheap, because of the low equivalent number of carbon, and the low price of coke and gas carbon; and powerful, because of the intense affinity of carbon for oxygen at high temperatures,—an affinity sufficient, indeed, to set the alkali metals free from their oxides. The nearest approach in these experiments to this object was with carbon and nickel in a fused mixture of soda, lime, and silica.

Many experimentalists have examined the stratified light of the electric discharge, and have assigned various causes for this curious phenomenon; they seem, however, all to have ended in the establishment of one fact only, that the alternate light and dark bands require for their production an imperfect conductor. M. L'Abbé Laborde † has lately succeeded in producing an analogous stratified appearance, and permanently fixing it on a plate of glass. For this purpose he prepares a glass plate with iodized collodion, and then lets it undergo all the operations customary in preparing a photographic image. It is exposed for a brief time to light, and then the silver is reduced by a developing agent. A surface is thus obtained which possesses an intermediate conductibility. The two ends of the induction wire being placed a little distance apart on the surface, the spark will produce stratification in passing from one to the other. A suitable surface cannot invariably be obtained; when the plate presents the appearance known as solarization, and has a reddish transparent tint, the surface is not sufficiently conducting, and the spark passes over without attacking it. If on the contrary the silver is completely reduced, and presents a metallic and mirror like layer, it conducts too well, and the

* 'Chemical News,' June 4, 1864.
† 'Comptes Rendus,' lviii. 661.

spark traverses without modifying it. Between these two extremes, surfaces are obtained on which the spark produces more or less complete stratification of very varied appearance. The designs traced by the electric current are transparent on an opaque surface, so that they can be copied directly on positive photographic paper.

It has not hitherto been possible to obtain a deflection of the magnetic needle by the secondary current of the Leyden battery, but by means of an apparatus which he calls the "electrical valve," M. P. Riess* has succeeded in obtaining evidence of this deflection, and has deduced the convenient rule that by means of the electrical valve, and in any position, the secondary current of the Leyden jar deflects a magnetic needle in the direction of a current proceeding from the disc to the point of the valve. M. Reiss describes a numerous series of experiments which show in a very striking manner the occurrence of the extra current in the circuit of the battery itself, and are not less conclusive than are the previous experiments of the author on the heating of the branches.

X. SANITARY SCIENCE.

That the weather exercises a considerable influence over the health of individuals and communities has long been a favourite article in the popular creed, and this belief has been embodied in many a wise saw and pithy proverb. But it is not only in such apophthegms that this conviction of the influence of the weather upon disease and mortality has been expressed; it has formed the subject of many laborious and learned memoirs, and since the time when Hippocrates penned his celebrated treatise 'On Airs, Waters, and Places,' it has taken a permanent position in the medical literature of all civilized lands. In more modern times the researches of Casper, Quêtelet, Boudin, Guy, Sir James Clark, and many others, have done much to throw light upon the effects produced by external causes on the constitution of the human frame. During the past year, the literature of this subject has received an addition, in the form of an elaborate memoir 'On the Influence of Weather upon Disease and Mortality,' † by Dr. R. E. Scoresby-Jackson, in which an endeavour is made to treat the subject in a somewhat more exact manner than has often been attempted. His investigations are restricted to the climate and death-rate in the eight principal towns in Scotland, and the data he has employed in the course of his inquiry have been furnished by the collected returns from the stations of the Meteorological Society of Scotland, and from the mortality tables constructed from the returns made by the Scottish Registrar-General. The period over which his investigations have extended is six years. At the outset of his memoir he lays down the following proposition, one, we think, to which

* 'Phil. Mag.,' series iv. p. 313.

† Transactions of the Royal Society of Edinburgh, 1863, and reprint.

sufficient attention is not at all times given :—"We are not to assume that because certain conditions of weather, as indicated by meteorological instruments in this country, are opposed to recovery from certain diseases, that therefore patients so suffering are not to be sent into any country where meteorological instruments afford exactly, or even nearly, parallel readings. In other words, in estimating the value of a foreign climate, or the different climates of our own country, we are not to depend so much upon a comparison of the meteorological data of the several places, as upon the meteorological data and the prevalent diseases and death-rate of one and the same locality. To argue that because a given condition of temperature, atmospheric pressure, and humidity, in Scotland, is accompanied by a certain ratio of mortality, therefore, meteorological data being equal, the same death-rate will be observable in Torquay or Madeira, would be most fallacious. All other things being equal, the death-rate would also coincide, but it requires much more than mere meteorological analogy to establish such a parallelism." From the materials employed by the author, the conclusions he has arrived at are to be regarded as applicable only to those localities in Scotland from which his data were obtained. With regard to the influence of temperature on mortality, he concludes that the relationship between mortality from all causes and mean temperature is inverse when the mean is below 50°, and direct when the temperature is higher, *i.e.* the relationship is inverse in winter, spring, and autumn, but direct in summer. Again a low winter temperature increases the mortality from phthisis pulmonalis, especially when it is very and continuously low, and both with it and bronchitis the relationship between mean temperature and death-rate is inverse all the year round. A high mean summer temperature increases infantile mortality. But in all statistical inquiries into the influence of temperature on mortality, in which the deaths occurring during a given period are compared with the temperature of the same period, it should never be forgotten that cold and heat do not necessarily act immediately, but that the diseases engendered or aggravated by them must run their course, and the deaths arising therefrom may be registered at a time when the thermometric scale exhibits a very different mean from that which it presented when the disease originated.

Again, the prevailing opinion that northerly winds act injuriously on health is confirmed by Dr. Jackson's tables, for a high death-rate attends winds blowing from a point between N.W. and S.E. (north about), whilst winds blowing from a point between S.E. and W. (south about) occur more frequently during months in which the mortality from all causes is low.

Many other interesting relations are suggested by the tables and diagrams with which the memoir is copiously illustrated, such as the relationship between the barometric pressure and the death-rate, and the influence of drought and humidity on mortality. But for an account of the results indicated or arrived at we must refer our readers to the original memoir itself.

Since the year 1851, when Schönbein communicated to the Medico-Chirurgical Society of London a memoir, in which he pointed out that the inhalation of ozonized air occasioned a painful affection of the chest,—a sort of asthma,—accompanied with a violent cough, the attention of the medico-meteorologist has been directed to the determination of the proportion of ozone in the atmosphere, and its relation, if any, to the prevalent diseases of the time or of the place.* Both in this country and in Germany careful registers have been kept of the variations in the amount of atmospheric ozone during a number of years. But we cannot as yet say that any very trustworthy results have been arrived at, as to the relations between its excess and deficiency, and the diseases which may have been most rife during the same period. This indefinite condition of the question may perhaps be in part explained by the somewhat inexact nature of the test employed. For, although the ozone papers may be sufficiently delicate to indicate absolute deficiency or excess of atmospheric ozone, yet the determination of minute shades of difference will vary much with the individual observer, with his power of appreciating the exact tint produced on his test paper, and of referring it to the corresponding shade on his reference paper. And it is, perhaps, to the difficulties which exist in comparing the results obtained by observers stationed in different localities, that we must, in some measure, ascribe the very different statements which have been made of its action on the animal frame. For whilst one set of observers declares that there is a remarkable coincidence between an excess in the amount of atmospheric ozone and the prevalence of affections of the respiratory passages,† on the other hand, M. de Piétra Santa ‡ states that at Algiers, where bronchial affections are rare, ozone exists abundantly in the atmosphere.

Again, the attempts which were at one time made to show that diseases of the alimentary canal, and even cholera, were more rife when the proportion of ozone in the air was small, have not been borne out by subsequent investigators.

More exact results of the power of ozone when in excess, to act upon the human frame may, however, be obtained by direct experiment, as when air is artificially ozonized, and animals are compelled to breathe it for a given period. This line of inquiry has now been followed out by various experimenters. Schönbein,§ Schwarzenbach,‖

* References to the following papers on the subject may prove useful to some of our readers :—

Spengler. Influenza und Ozon. Henle u. Pfs. Zeitschrift, vii. 1. 1848.

Heidenreich. Ozon und Katarrh. Neue med. chir. Ztg. vii. 3.

Clemens. Wirkungen Ozonzerst : Gase auf den Mensch : Organismus. Henle. u. Pfs. Zeitschrift, vii. 2. 1848.

Annales d'Hygiène publique. Paris. 1863. P. 439.

† This side of the question has been very recently advocated by Dr. Hjaltelin, of Reikjavik, in an able paper on "Epidemic Pneumonia in Iceland," in the year 1863, published in the 'Edinburgh Medical Journal,' May, 1864.

‡ 'L'Union Médicale,' 30 Mai, 1861.

§ Henle und Pfs. Zeitschrift. N. F. Bd. 1. S. 384.

‖ Canstatt's Jahrb. 1851. 1, 128.

Böckel,* and Desplats,† have all confined animals in air, ozonized either by means of phosphorus or by passing electric sparks through it. In every case, the animals died with symptoms of affection of the respiratory organs, though Schwarzenbach thinks that the nervous system, and more especially the *nervus vagus*, was also involved. During the past year, another series of experiments has been recorded by Dr. W. Ireland,‡ from which he has been led to form the following conclusions:—

1st. Ozonized air accelerates the respiration, and, we may infer, the circulation also.

2nd. Ozonized air excites the nervous system.

3rd. Ozonized air promotes the coagulability of the blood, probably by increasing its fibrine. In the blood, however, ozone loses its peculiar properties, probably entering into combination with some of the constituents of the circulating fluid.

4th. Animals can be subjected to the influence of a considerable proportion of ozone in the air for hours, without permanent injury; but in the end, ozone produces effects which may continue after its withdrawal, and destroy life. In ozonizing the air for his experiments, Dr. Ireland pursued a plan differing from that adopted by his predecessors. He introduced sulphuric acid and permanganate of potash into a glass bottle, and collected the ozonized air, produced by their action on each other, in a glass jar under water. This method seems to present decided advantages over the plan commonly pursued, of burning phosphorus in air. For in this latter process, not only are fumes of phosphoric acid generated, which it is not very easy to get rid of, but a part of the oxygen of the air is consumed in the combustion, and its proportion to the nitrogen, therefore, necessarily diminished.

Whilst on the subject of ozone, we may notice some recent experiments by A. Schmidt,§ which seem to show that ozone, or a substance capable of producing it, exists in the blood. Instead of employing iodide of potassium as the reagent for the ozone determination, he used strips of paper soaked in a tincture of guaiacum (1 part wood to 6 parts alcohol), and when the alcohol had evaporated, a drop of blood was added to the paper. A blue ring appeared in the course of a few minutes, where the layer of blood was the thinnest. The depth of colour of the ring varied with the blood employed: with that of the ox and horse it was the strongest; with that of man, without the addition of water, feeble; and with birds' blood, not at all, until after the addition of water, and then strongly. Pure colourless serum did not act at all. Schmidt considers the hæmatin of the blood-corpuscles to be the ozone-producing material. He also noticed the oxidizing action of the blood-corpuscles on a solution of indigo. Schmidt concludes that in the blood a quantity of oxygen ready to become ozone

* Thèses de Strasbourg, 1856.
† Thèses de Paris, 1857.
‡ 'Edinburgh Monthly Medical Journal,' February, 1863.
§ Ueber Ozon im Blute. Dorpat. 1862.

exists. When putrid, the blood lost its power of affecting reagents, though four weeks after having been drawn, it was not quite inactive.

Before closing our chronicle, we may direct attention to the report by Messrs. Hewlett, Stanley, and Reed, on the ventilation of the new barracks, at Gravesend, contained in the recently-issued statistical sanitary and medical reports for the Army Medical Department.* The observations made by these gentlemen show the importance of attending to the organic impurities floating in the atmosphere, and they bear out in many respects the conclusions arrived at by Pouchet and others. The method they employed was to draw the air, by means of an aspirator, through a solution of permanganate of potash, of known strength. The liquid became discoloured during the experiment, and a deposit occurred. This deposit was examined microscopically and found to contain fragments of epithelium, pus-cells, pieces of cotton fibre, shreds of wool, and large numbers of amorphous bodies. Dr. Parkes, in his remarks on these and other allied observations, points out that they put in a clearer light than before the necessity of ventilation, and the advantage of isolating patients, from whose bodies arise such quantities of organic particles. They would also seem likely to put on an experimental basis the doctrine of the transference of morbific agents from one person to another. The volume contains, besides, a large amount of very instructive matter, not only as regards the health of the British Army, but on sanitary questions generally.

XI. ZOOLOGY AND PHYSIOLOGY.

(*Including Proceedings of the Zoological Society of London.*)

The two topics which have received the greatest attention during the past quarter are the discoveries of M. Lartet, respecting the co-existence of man and the reindeer in central France, and the theory of Dr. Hunt as to the Negro's place in nature. The former subject comes perhaps more strictly within the range of the palæontologist, still it will not be out of place here to mention, that seventeen stations have been discovered in France where the presence of the reindeer has been ascertained in a state of subjection to man; but as to the epoch when the reindeer ceased to inhabit what is now temperate Europe, there is no positive historical or chronological account. Its remains are not even found in the French turbaries, nor in the Swiss lacustrine pile-works; but remains are found in a cave of Mont Salève, in which they are associated with simply worked flints; and in the grottoes of Perigord are found flint flakes, and utensils and weapons manufactured of the horns and bones of the reindeer.†

* London, 1863.

† A very interesting account of these remains, accompanied by illustrations, will be found in the letter of our Paris correspondent. ("Notes and Correspondence.")

With regard to Dr. Hunt's views of the Negro's place in nature, his paper proposed to show, that in the proportions of the arm, the form of the hips, thighs and fingers, the flatness of the foot, and the size of the molar teeth, there appeared a nearer approach to the ape than was seen in the European. The brain was comparatively small, the facial angle low, and all development of the brain ceased at puberty, while the form of the skull became more ape-like as he advanced in years. The structure of the brain was distinct from that of any other race of man; and it had yet to be established whether the offspring of the European and Negro were indefinitely prolific. There was not a single instance of a pure Negro being eminent in science, literature, or art; and Dr. Hunt concluded from all his observations, that there was as good reason for classifying the Negro as a distinct species from the European, as there is for making the ass a distinct species from the zebra,—that the analogies are far more numerous between the Negro and apes, than between the European and apes—that the Negro is inferior, intellectually, to the European—that the Negro is more humanized when he is in his natural subordination to the European than under any other circumstances—that the Negro, indeed, can only be humanized and civilized by Europeans, and that European civilization is not suited to the requirements and character of the Negro.

These premises evoked a considerable amount of discussion at the time the address was delivered, in which, although some were decidedly opposed to the whole theory, the balance of opinion appeared to be in Dr. Hunt's favour. Subsequently, Professor Huxley, in his Hunterian lecture, alluded to the paper for the purpose of condemning it, which called forth a paper war in the columns of the 'Reader,' between Dr. Hunt, Mr. C. Carter Blake, and Professor Huxley. This discussion, however, which promised to be a very acrimonious one, and was not carried on with the most desirable courtesy, was nipped in the bud by the reticence of the Professor, who having had his word, let the matter drop, and returned no response to the replies of the leaders of the Anthropological Society.

M. Gratiolet has been discoursing upon Man's place in nature, and his remarks are, of course, worthy of great attention. Speaking of the brain of the apes, he says: "There is an enormous posterior cornu with lateral ventricles, and it occupies all the interior of the posterior lobes of the hemispheres. This fact has been denied by Professor Owen, but his error is obvious." He goes on to observe that the encephalon of man and that of the apes present a typical resemblance, and this resemblance is exclusive—man resembles the apes and the apes only. All the differences relate to secondary characteristics—the volume, complication, and reciprocal proportions of the parts. But at no epoch is the human brain, typically so like an ape's brain, actually an ape's brain. One can make of material man neither a kingdom, a division, a class, an order, nor a family of an order. He is apart from the beings which most resemble him. He also compares *the hand* of the ape and man. In the former, in reality, the hand is free only when the animal is at rest, and this liberty reduces itself to the movements of brutish prehension. What a difference is there in the hand of man! From a simple prehensile organ it becomes a measuring instrument—from a hook it becomes a compass, and the compass presupposes the geometrician. With regard to the disputed question of the *Negro's* place in nature, M. Gratiolet exclaims—"Do these races (*i. e.* the Negroes and certain other degraded races) form a passage between man and the apes? No—a thousand times No! Their deformity even protests against such an assertion. Far from dwindling down, the human characteristics become more decided, and even exaggerated in their case. The lobe of the ear, the nostrils, the lips, which are the exclusive character of man, are developed even to deformity. Everything in the Negro's degraded face protests against this impious assertion."

The Society of Arts and Sciences of Utrecht has propounded some questions for which it is proposed to give prizes, *viz.* for each a gold medal, value 300 Dutch florins. The following relate to the subjects under consideration:—1. Observations on the influence exerted by small variations of exterior circumstances upon the evolution of the embryo of one or more species of vertebrate animals. 2. Chemical and physiological observations on the digestion of freshwater fish. 3. Chemical and physiological observations on the digestion of reptiles. 4. It has long been known that fish have the faculty of producing sounds; the Society requires observations on the manner in which the sound is produced in one or more species where the cause has not yet been pointed out. 5. Observations upon the development of one or more species of invertebrate animals, the history of which is not yet known, accompanied by the figures necessary to explain the text. The successful essays will be published in the memoirs of the Society, and all replies must be sent to the Secretary, Professor O. Van Rees, Utrecht, before the 30th November next.

In a paper by Dr. W. H. Dickinson, read before the Royal Society, upon the Functions of the Cerebellum, he infers from numerous experiments upon the lower animals, that the cerebellum has nothing to do with cranium sensations, with the sexual propensity, with the action of the involuntary muscles, with the maintenance of animal heat, or with secretion; but the only function which his experiments seemed to assign to it was such as concerns voluntary muscles, which receive from it a regulated supply of motor influence. Each lateral half affects both sides, but the one opposite to itself the most. The anterior limbs are chiefly under the influence of the cerebrum; the posterior, of the cerebellum. Cerebellar movements are apt to become habitual, while cerebral are impulsive. In the human subject, the only faculty which constantly suffers in consequence of changes in the cerebellum is the power of voluntary motion. When congenitally defective, there is want of action in the muscles of the lower extremities. The occasional occurrence of loss of visual power, and alterations of the sexual propensity in diseases of the cerebellum, are referred to the conveyance of irritation to the *corpora quadrigemina* in the one case, and to the spinal cord in the other. From all experiments on animals and on man, it is concluded that the cerebellum is a source of voluntary power to the muscles supplied by the spinal nerves. It influences the lower more than the upper limbs, and produces habitual rather than impulsive movements—and it has a power, which has been described as that of *co-ordination*—and it is suggested that the outer portion of the organs may be the source of its voluntary motive power, while its inner layer is the means of regulating its distribution.

Mr. Rowley, of Brighton, has recently added to his collection the only egg of the *Æpyornis maximus* which ever came to this country, and has in a shilling pamphlet, published by Trübner and Co. (and noticed amongst our reviews), made some interesting observations, not only on the unique zoological specimen, but upon the bird which laid it.

G. O. Sars, son of the celebrated Norwegian Professor, has been dredging in freshwater lakes in Norway, and has met with some curious confirmations of former observations, that true inhabitants of the sea can, under certain circumstances, gradually accustom themselves to live in thoroughly fresh water. The conditions of change, as exhibited in some Swedish lakes to Professor Lovén, may be very gradual, operating throughout thousands of years, but, in the present instance, it must have been much shorter. Sars found in the mud at the bottom of this lake a small red crustacean, in which he at once recognized a saltwater species, although the water was perfectly fresh and pleasant to the taste. In the case of this lake, apparently some very high flood, or a furious storm from the west, has driven the sea up on some occasion into the loch, which lies close to the coast. Their residence in a foreign medium, however, appeared to have changed the mode of life of these animals, for, instead of being found as usual in the shallowest pools, they were here in the deepest part of the water, sunk in the mud. Dredging in Mjösen Lake, which flows through a large river, he discovered a crustacean, *Mysis relicta*, of Lovén, belonging exclusively to salt-water ; one of those extraordinary relics of the glacial period, whose presence in some of the great inland lakes of Sweden has lately excited so much interest. Associated with it were numerous examples of a Gammarus (*G. cancelloides*), first discovered in the seas of Baikal and Angora, and which has lately also been found in Sweden, and which Lovén considers originally to have belonged to the sea.

These observations of Lovén and Sars may tend to modify materially certain geological theories.

A valuable and interesting paper has been communicated to the Linnæan Society by Mr. A. R. Wallace, on the 'Phenomena of Variation and Geographical Distribution as exhibited by the Malayan Papilionidæ.' The large butterflies of this region are well adapted for this purpose, since their gaily-painted wings register the minutest changes of organization, and exhibit on an enlarged scale the effects of the climatal and organic conditions which have influenced more or less profoundly the organization of every living being. The variations occurring among the 120 species inhabiting the Malayan Archipelago are classed by Mr. Wallace under the heads of, 1st, simple variability ;

2nd, dimorphism or polymorphism; 3rd, local forms; 4th, coexisting varieties; 5th, races or sub-species; and, 6th, true species. The first includes all great instability of specific form; the second, polymorphism or dimorphism, differs from the first in this—that the offspring differs from the parents in a considerable degree, and in a manner more or less constant and regular—so that, of the offspring of a single pair, some will resemble their parents, while others will differ from them, but the difference will be tolerably fixed and definite, and intermediate varieties will never occur. He explained how such a state of things came about in a Philippine island butterfly, *Papilio alphenor.* But the most interesting portion of his observations was directed to the subject of variation as specially influenced by locality, for example, the fact that the species of this Indian region (Sumatra, Java, &c.) are almost invariably smaller than the allied species of Celebes and the Moluccas. The most remarkable of these cases was that of the island of Celebes, almost all the Papilionidæ, Pieridæ, and some of the Nymphalidæ of which had acquired a peculiar curve of the upper wings, amounting in some instances to an abrupt bend. If, he argues, the butterflies of the Celebes acquired their longer and more curved wings owing to the persecution of bird or insect enemies, from which they could only escape by increased powers of flight, it is evident that those which had already some other means of protection would receive no benefit from a change in the form of their wings, and therefore could not acquire it by the action of *natural selection.* This also explains why none of the Danaidæ are so modified, for they are universally the objects of mimicry by other groups, and are therefore already protected. These Danaidæ are a nuisance to the collector from their abundance and ubiquity, and their strong and peculiar odour is believed to be the cause of their safety, and they are, for this reason, habitually passed over by insectivorous creatures. Mr. Wallace, therefore, with Mr. Bates, argues that mimicry is in all these instances a means of protection.

In a discussion which recently took place in the Entomological Society with reference to the luminosity of fire-flies, Mr. Bates remarked that the Honduras fire-fly (*Fulgora lanternaria*) was pretty common in the upper Amazons, but he had never found it luminous; moreover, although the creature figured in their fables, and was reputed to be poisonous, there was no rumour current among the natives of its being luminous.

M. Siebold has communicated to the Helvetic Society of Natural Sciences a curious fact of parthenogenesis of bees. A hive at Constance furnished for four years a considerable number of hermaphrodite bees, which immediately after their hatching are expelled from the hive by the workers. None of these individuals resemble one another; sometimes one side is male and the other female, or the anterior parts (head, eyes, antennæ, &c.) are of one sex, while the posterior belong to the other; while sometimes the internal apparatus belongs to one sex and the external to the other. Some individuals are, in the interior, males on the right side and females on the left, while the reverse is the case on the exterior. The eggs from which these hermaphrodites issue, are laid in the workers' cells, and ought, therefore, to become workers, but the queen-bee, having probably some defect in organization, a part of these eggs are only incompletely fecundated, so that the development of the female organs remains in a more or less rudimentary condition.

The cultivation of silkworms is so important a branch of industry in some portions of the globe, that any information respecting their diseases and modes of cure becomes highly valuable. Captain Hutton, F.G.S., of Mussooree, N.W. India, attributed the enormous loss of worms by "muscardine" and other diseases to the combined effects of bad and scanty food, want of sufficient light and ventilation, too high a temperature, and the constant interbreeding for centuries of a debilitated stock. He regards, after long experience, the occasional occurrence in a brood of one or more dark grey or blackish brindled worms, —the *vers tigrés*, or *vers zébrés*—as an attempted return, on the part of nature, to the original colours and characteristics of the species; in fact, the dark worms, hitherto rejected by the sericulturist, were the original and natural worms, and the whiteness or pale sickly hue of the majority was a positive indication of degeneracy and the destruction of the original constitution. He recommends the sericulturist to separate his dark worms from the general stock, and to set them apart for breeding purposes, thus annually weeding out all the pale-coloured worms.

M. Onesti has found that wood-soot, if sprinkled over silkworms attacked with *fébrine*, effects an almost certain cure, or, at all events, prolongs their lives until the cocoons are finished. The French Minister of Agriculture has addressed a circular to the *préfets* of the sericultural departments of France, and has requested that a commission be formed to report on the value of M. Onesti's discovery.

Professor N. Wagner has discovered a fact in natural history, which at first sight appears incredible; but it is supported by preparations, an inspection of which has convinced Professor de Filippi of the truth of the observations. Professor Wagner found in June 1861, under the bark of a dead elm, some whitish apodal worms, which proved to be the larvæ of insects. Each larva was filled with smaller larvæ, at first supposed to be parasitic; but the smaller larvæ were found upon closer examination to be identical, even to the smallest details, with the enveloping larvæ, by which identity Professor Wagner was led to assume that the included larvæ represented a second generation produced by the enveloping larva. This would be a case of alternation of generations, even more surprising than that of the aphides; and this interpretation has several circumstances in its favour, *viz.* the identical character of the inclosed and enclosing larvæ—their simultaneous development—the presence of enclosed larvæ not in some but in all the larvæ—and, lastly, that in the interior of the larvæ of the second generation, a *third* generation is produced precisely similar to the first two. Professor Wagner has observed three other species of the same genus, all presenting this singular mode of reproduction. The perfect insects are still unknown, but from the appearance of the larvæ, they seem to be of the order diptera.

We read in 'Cosmos' a letter from M. Duchesne Thoureau relating to a pattern taken from a large *tapis*, entirely due to the work of a group of spiders in a state of captivity. He expresses his belief that it is quite possible to produce by the aid of such auxiliaries, and without expense, soft and warm carpets, to arrive at which results it would only be necessary to dispose of a number of working spiders, and over a space proportionate to the magnitude of the work desired.

From the works of Oersted, Grube J. Müller, &c., it appears that the genus *Autolytus* presents the peculiarity so rare among Aurelids of a striking polymorphism, the males being so different from the females, that the two sexes have been described as belonging to distinct genera. There exists also in each species a third form, namely, the asexual form, which produces the sexual individuals, by gemmation at its posterior extremity, the alternation of generations in these worms being thus well established. M. A. Agassiz has found in the harbour of Boston, the *Autolytus* of which the males were described by Oersted in 1843, from Greenland, under the name of *Polybostrichus setosus*. He has, likewise, observed in the same locality, another species, to which he has given the name of *Autolytus cornutus*, a species which appears to be nearly related to the European species, *A. Heligolandiæ*. The differences between the individuals of the two sexes are of the same nature as in the European species. The females, at the moment of their detachment from the organic individuals, possess no ovigerous sac, but it is soon formed, and the ova deposited in its interior. The embryos are rapidly developed, and their escape from the sac appears to cause the death of the female, for M. Agassiz has never met with females after their embryos have escaped. The embryos at the moment of issuing from the sac have a triangular outline, their body diminishing rapidly towards the posterior externity.

The frequency with which the minute parasitic worm, *Trichina spiralis*, has been found of late in the muscles and intestines of the pig, and the fatal and serious results which have attended the consumption of flesh so contaminated, has spread a panic throughout Germany, and a committee has been appointed by the Berlin Medical Society, consisting of Virchow, Remak, Gurlt, and others, to examine into and report upon the subject. Thus far the disease has not been met with in any animal that is a vegetable feeder; but Dr. Langenbeck says, that *trichinæ* have been found in extraordinary numbers in earthworms last year—as many as 500 or 600 having been observed in a worm of middling size—and these worms form part of the food of those animals which swine devour when left at liberty. He advises that the swine should be always fed in styes, and debarred access to localities where worms are numerous.

It is seldom that a natural object proves so complete a puzzle to the initiated as one which has recently been brought to light. It is an elongated semicylindrical body, whitish, and rough like shagreen, length about two feet. It was purchased by the Rev. H. H. Higgins of a dealer in London, for the Liverpool Museum, where, struck by its remarkable and anomalous character, he showed it to Dr. Gray, who took it to London. It has been examined by Milne-Edwards, and other *savants*, but no one appears able to identify it. The impression is, that it is echinodermatous in its nature, and it has been provisionally named by Dr. Gray *Myriosteon Higginsii.* This remarkable object has been transferred to the National collection in the British Museum.

The Zoological Society of London.

Little of general interest has transpired at the meetings of this Society during the past quarter, the most important communications being those of the Secretary, Dr. Sclater, either from persons residing abroad, or his own observations upon recent arrivals, and upon the animals in the Society's gardens. Perhaps, the most interesting communications were those relating to the collection of animals made by Captain Speke, during his expedition to Eastern Africa.

Dr. Sclater described the mammals and birds; Dr. Günther, the reptiles and fishes; Dr. Dohrn, the mollusca; and Mr. F. Smith, the insects collected by the great African traveller. Thirty-eight species of mammals were enumerated, amongst which the most remarkable was a new antelope of the genus Tragelaphus, which it is proposed to call *T. Spekii;* and sixty-one birds, including five new species.

This was at the meeting on the 8th of March. Mr. F. Buckland also read an interesting communication upon the habits of the spawning trout. He had learned easily to distinguish between the male and female at a glance as they swam; the male is always long in body, and generally has a hook-like projection from the lower jaw, the colour of the abdomen always chocolate, and a white line running along the pectoral fin, and usually on the ventral also. The female is shorter and rounder, and more wild and timid. He had succeeded in hybridizing the salmon and trout, and hoped in time to naturalize in the Thames a fish two parts trout and one part salmon, which should so combine the habits and excellencies of the two, that the non-migratory instinct should predominate over the migratory, and the fish thus be induced to remain up river.

On the 22nd March the Secretary drew attention to some recent additions to the ménagerie, the most remarkable of which were a young American monkey (Pithecia Satanas), and four examples of the Rufous-tailed pheasant (Euplocamus erythrophthalmus), the latter having been presented to the Society by their corresponding member, the Baboo Rajendra Mullick, of Calcutta.

These birds formed part of a collection brought over by Mr. J. Thompson, the Society's head-keeper at Calcutta, and presented by the native gentleman just named. Mr. Thompson had so ably managed the transport from Calcutta, as only to have lost a single bird on the passage.

Amongst other arrivals announced by Dr. Sclater (April 12th) was a living example of the tooth-billed pigeon (Didunculus strigirostris), presented to the Society by Dr. George Bennett, of Sydney, along with some other rare Australian birds. At the subsequent meeting, April 26th, Dr. Sclater announced that Mr. Latimer, the Austrian

Consul at Porto Rico, had offered, through Lieut.-Colonel Cavan, to obtain for the Society some living Manatees (Dugongs), and that arrangements were being made for the transport of the animals to this country.

Amongst the papers descriptive of new collections, read by the Secretary (the specimens being, in some cases, exhibited), was one of birds collected by Rev. H. B. Tristram, now in Palestine. Amongst these were two new species, which Mr. Tristram proposed to call *Passer Moabiticus*, and *Caprimulgus Tamarioca*. Also a paper referring to a collection made by Mr. G. H. White, in the vicinity of Mexico, amongst which were several additions to the avi-fauna of that country, and other papers describing single examples of special interest to zoologists.

At the meeting on the 22nd of March, Dr. Günther read the first part of an account of a large collection of fishes made by Capt. Dow, and Messrs. Salvin and Gorman, at Panama, among which were many new and interesting species. He pointed out the structure, and mode of operation of a poison apparatus in a new species of fish of the genus *Thalassophryne*, belonging to the family *Batrachidæ*, which it was proposed to call *T. reticulata*. The poison organs consist of four hollow spines, two of them being dorsal, and the others formed by the acute termination of the operculum posteriorly. The canal in the interior of the spines terminates in each case in a sac, in which the poisonous fluid is collected. In the specimens examined by Dr. Günther, which had been preserved in spirits for nine months, the slightest pressure of the sac, situated on the operculum, caused a whitish fluid contained in it to flow freely from the hollow extremity of the opercular spine.

In the account of this apparatus, which appeared in the last number of the 'Natural History Review,' it was stated that, "although many fishes have long had the reputation of being considered poisonous, no trace of any poisonous organ has been detected in them." This is an error. In the Proceedings of the Liverpool Literary and Philosophical Society, No. V. p. 156, is an excellent account of the anatomy of the stinging organs of the sting-fish, or Lesser Weever (Trachinus vipera), by Mr. I. Byerley, F.L.S., Seacombe, Birkenhead, accompanied by illustrative plates. In this paper the existence of poison glands in connection with the dorsal spines is demonstrated, and the character of these organs in our well-known British fish appears to be very similar to that described by Dr. Günther, in the *Thalassophryne* from Panama.

One or two communications of interest have been made by Dr. J. E. Gray, F.R.S. On the 24th May, that gentleman described the cetaceous animals which have been observed in the seas surrounding the British isles, of which he enumerated twenty-eight species as having occurred on the coast of this country. At the same meeting he read a note upon *Urocyclus*, a new genus of terrestrial gasteropodous mollusks, discovered by Dr. Kirk (of Dr. Livingstone's expedition), in the Zambesi river. On March 8th, Dr. Gray described a new species of tortoise, discovered by Mr. Osbert Salvin, in Guatemala, to be named *Staurotypus Salvinii.* He also read a paper upon the Chelydidæ, as distinguished by their skulls; and gave a synopsis of the sand-moles of Africa, including a description of two new species discovered by Captain Speke.

Amongst the notes read at the various meetings were the following:—by Mr. Flower, of the Royal College of Surgeons, on a lesser Fin Whale (Balæna rostrata), stranded upon the coast of Norfolk; by Dr. E. Crisp, on the Anatomy of the Eland; by Dr. Geo. Bennett, on the habits of the tooth-billed Pigeon (Didunculus strigirostris); and by Mr. J. K. Lord, upon the use of a shell of the genus *Dentalium*, as a currency medium by the natives of Vancouver's Island, British Columbia.

XII. CHRONICLE OF RECENT SCIENTIFIC PROGRESS IN AMERICA.

By Henry Draper, M.D., Professor of Natural Science in the University of New York.

Since the breaking out of the civil war in the United States in 1861, a strong military tendency has been communicated to scientific pursuits. This is well seen in the records of the Patent Office at Washington, where, during the past three years, not less than 1,140 improvements in cannon, projectiles, cartridges, &c., have been patented. A considerable number of these refer to attempts at producing breech-loading weapons of large calibre. The application of this principle has thus far been unsuccessful, and probably will continue to be so, on account of the difficulty of securing strength without unwieldiness. In smaller cannon it has been partially successful, while in fire-arms it has done so well as to give rise to serious discussion concerning the propriety of abandoning muzzle-loaders altogether.

The most effective artillery that the war has produced has been the Parrot rifle, and the Rodman hollow-cast 15 and 20 inch guns. The former consists of a cast-iron barrel, strengthened at the breech by a reinforce of wrought iron. The durability of these weapons is so great, that a 30-pounder used against Charleston was fired 4,615 times before bursting. The range was five miles. The largest size as yet furnished for active service is a 300-pounder; many 200-pounders have been made.

For heavy battering purposes and the destruction of iron-plated vessels, the Government has encouraged the construction of smooth-bore cannon of great calibre; one of the forts in New York harbour having a battery of 15-inch guns, carrying 440-pound balls. The efficacy of these was tested in the battle between the 'Atlanta' and 'Weehawken,' in which the latter virtually decided the contest by the first discharge of her 15-inch gun prostrating 40 men.

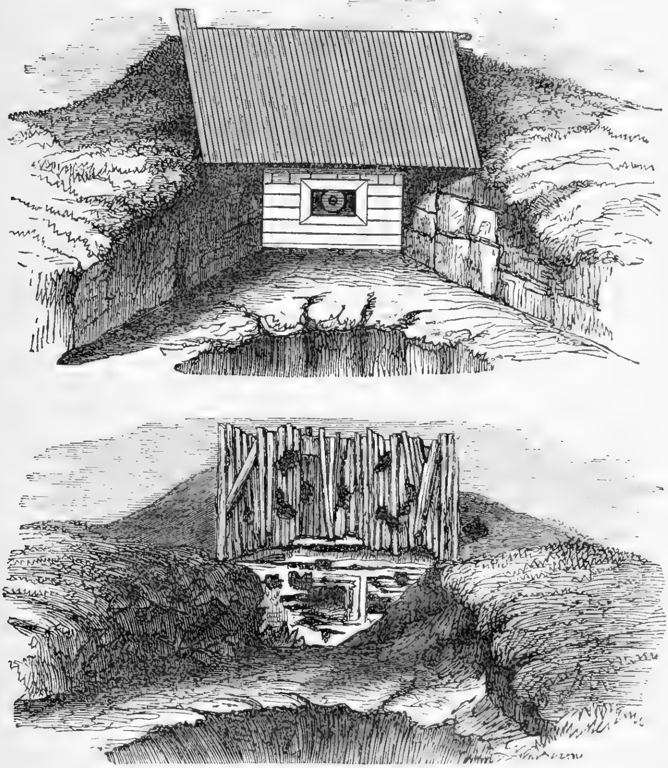
A 20-inch gun too has been recently successfully cast at Pittsburg on Rodman's principle. In order to make this monster piece of ordnance, which will throw a solid shot of 1,000 pounds, 104 tons of metal were melted, though the gun will only weigh, when finished, 56 tons. The essential feature of this system of casting is to cool the iron mass from the interior by means of a stream of water, which is sent to the bottom of the bore in a properly protected pipe, while the exterior is kept hot by a fire round it. In this instance air was substituted for the water after a certain length of time, as the water was found to lower the temperature of the metal too quickly. The running of the iron occupied only 21½ minutes, and the gun was ready for the lathe in a fortnight. These hollow-cast guns are also very durable, the 15-inch at Fortress Monroe having been already fired 505 times.

The use of gun-cotton, which is attracting so much notice on account of the Austrian experiments, has not met with favour. Up to the present, it has only been the solution in ether and alcohol that has been rendered available. By the aid of a coating of collodion, a cartridge of compressed gunpowder is made perfectly waterproof, and yet may be inflamed by a percussion cap without being torn open by the soldier. The advantage in rapidity of loading and freedom from dampness is very obvious.

Much attention too has been directed to defensive as well as offensive warfare. Iron-plated vessels in large numbers have been built, the Government having a fleet of 75 on hand, or to be soon completed. The favourite style of protection has been with many layers of plates bolted or riveted together, and, where possible, backed with two or three feet of oak. A few vessels with solid plates of 4½ inches thickness have been constructed; but since it has been found that the 21-inch gun with cast-iron round shot would penetrate such armour, they are no longer regarded as perfectly protected. The 'New Ironsides,' a ship of this kind, has, however, done well, not less than ten 10-inch shot having struck her near the water line, without doing any serious damage. She has been hit 213 times without losing a man.

When a person enters a Monitor turret, he cannot fail to feel a sensation of absolute protection, surrounded as he is on all sides by 11 inches of iron. The only loss of life in these structures has been from boltheads flying off; but now that the use of through bolts has been dispensed with, this cause of insecurity no longer exists. In the iron-clad cruiser 'Dictator,'—320 feet long, 50 feet beam, and 20 feet depth of hold—which is at present making ready for a trip to Europe, the turret has been increased to 15 inches, and the side plating to 11 inches, with three feet of oak. She is expected to be quite fast, having two 100-inch cylinders of 4 feet stroke. The armament is only two guns, but they are of built-up wrought iron, and of 13 inches calibre. The maker, Mr. Ericsson, is to receive 1,000*l.* for every pound of powder over 50 pounds that they will burn. The risk of encountering a sea voyage has already been undertaken by Mr. Webb, who has just sent the 'Rè d'Italia,' iron-clad 44, to Naples. She made the passage in 18 days and 18 hours, though the sea was so rough that the accompanying Italian frigate was almost lost.

As regards the protection of forts by iron, a paper has been written by General Barnard, in which it is shown that the only parts necessary to be protected in sea-coast works are the embrasures. In landworks he suggests having turrets in the salients, and, perhaps, sheathing the scarp wall. In the constructions of this kind, hitherto tested under fire, the plating has been with a double layer of railroad iron. After the capture of Fort de Russy, some experiments were made on such casemates, when it was found that they were very soon wrecked by the fire of 9-inch guns. The appearance in the figure shows the effect on casemate No. 2, at Fort Hindman, of the fire of the iron-clad 'Lexington,' at 400 yards. It is copied from the official drawing.



The most interesting mineralogical novelty is the development of petroleum boring. The quantity of this fluid exported during the past year was about 28,000,000 gallons, and the amount derived from its sale 2,400,000*l.* The export in 1861 was 1,112,476 gallons; in

1862, 10,887,000 gallons. The total production in 1863 is estimated at 80,000,000 gallons.

The greater proportion is obtained from Oil Creek Valley in Pennsylvania. Many of the borings are 500 feet deep, though some much less deep have yielded largely. These latter, however, required pumps, while the former, called "flowing wells," eject their contents in some cases to a height of 100 feet above the ground. The petroleum is discharged by pipes into vats, where the salt water with which it is associated separates. In this state it is worth about fourpence a gallon, though there have been occasions, when the market was glutted, in which it has sold for not more than two shillings a barrel of 40 gallons. The owners of the wells are now able to control the discharge by stopcocks fixed on the pipes that line the borings, and when the price is low, limit the supply.

Crude petroleum has to be submitted to distillation in order to separate the benzine, which boils at 140° F. from the heavier oils, and these, in their turn, from the solid hydrocarbons. The proportion of these ingredients varies so greatly (some wells producing so large a percentage of the heavy oils), that the product is only suitable for greasing machinery. Unfortunately, it "gums," as mechanics say, and unless tallow or animal oils are added to it, it cannot replace sperm oil.

The exact source of petroleum is, up to the present, uncertain, whether it has all been produced by distillation from bituminous coal, anthracite being formed at the same time, or whether it has resulted directly from the bituminous fermentation of marine plants antedating the coal and containing a larger proportion of hydrogen.

The amount thrown out by some of the wells is enormous. One of them ejected 3,740 barrels a day, three 1,000 barrels, one 800 barrels. To "strike ile," has become throughout that region the synonym for rapidly growing wealthy. Transportation to market is effected by carrying it down the stream in vessels, many of which are merely tanks. Occasionally, when collisions occur, thousands of gallons are lost, floating away on the surface of the water. It is proposed to collect the fluid again by means of floating dams, shaped like a V, with the point up stream.

The effect that this illuminating agent has produced throughout the country is very striking. It has entirely displaced all other means of lighting, except gas, and is used even in cities by many who desire an absolutely steady light. The great desideratum is, a perfect chimneyless burner. The petroleum requires a large amount of air for complete combustion of its carbon, and by no other means than a tube 6 or 8 inches long has the supply been rendered sufficient. Although by the substitution of mica for glass the difficulty of breakage has to a certain extent been overcome, there is still great room for improvement.

Kerosene, as the oil suited for burning is called, has in one sense increased the length of life among the agricultural population. Those who, on account of the dearness and inefficiency of whale oil, were accustomed to go to bed soon after sunset, and spend almost half their time in sleep, now occupy a portion of the night in reading or other amusements; and this is more particularly true of the winter season.

Benzine has come largely into use to supply the place of turpentine, especially for painting. It seems to be a good substitute for that now almost unpurchasable commodity, though painters have been forced to change their processes of mixing.

Professor Wolcott Gibbs has recently investigated the relations of hyposulphite of soda to certain metallic oxides. He finds that it can be used instead of sulphydric acid in precipitating nickel, cobalt, iron, alumina, zinc, and manganese from their solutions, if the mixture be raised to 120° C. In the old process as suggested by Himly, the temperature employed was not greater than the boiling point at the ordinary pressure of the air, and the reduction, though occupying several hours, was often incomplete. Gibbs uses a combustion tube hermetically sealed, heating it in an air bath for about an hour.

Mr. M. Carey Lea has examined the influence of ozone and some other chemical agents on germination and vegetation. He finds that ozone tends to check the growth of young plants; wheat in air growing 10 inches, while that exposed to ozone grew 4 inches. Ozonized air also diminishes the length of the roots, those exposed to it only becoming $\frac{3}{16}$th of an inch long, while the others increased to $2\frac{1}{2}$ inches. He concludes, that though ozone is a highly oxidizing agent, it may in some cases put a stop to putrefaction, by destroying the low order of vegetable organisms, which Pasteur has shown to be to a large extent the medium of effecting such changes. Mr. Lea has also noticed that oxalic and picric acids, even in very weak solutions, entirely prevent germination. The seeds were placed in all these experiments on gauze, resting on the surface of water.

Some facts regarding the great mass of copper found in the Minnesota mine, 120 feet below the surface, have been lately published. It was 45 feet in length, 22 feet at the greatest width, and 8 feet at the thickest part. It weighed 420 tons, and contained 90 per cent. of copper.

Mr. James D. Dana has continued the publication of his memoir on the classification of animals, based on the principle of cephalization. It is also being printed in England.

Professor J. D. Whitney is steadily progressing with the geological survey of California. The maps are mostly on a scale of $\frac{1}{2}$ inch to the mile. He has discovered that Mount Shasta, 14,440 feet high, probably overtops all other peaks in the United States; Popocatapetl, 17,783 feet high, the loftiest mountain in North America.

Professor Charles A. Joy has given the analysis of a meteorite found in Chili, weighing 1,784 grammes; it contained—

Nickel iron	(with Co, Mn, and Cu)	48·689
Sulphide of iron	$Fe\ S$	7·405
Chrome iron	$Cr_2\ O_3\quad Fe\ O$	0·701
Schreibersite	(Fe 1·38 Ni 0·67 P 0·115)	1·563
Olivine	$R\ O_3\quad Si\ O_3$	11·677
Labradorite	$(R_2\ O_3\ Si\ O_3 + 4\ R\ O\ Si\ O_3)$	29·852
Tin stone	$Sn\ O_2$	0·189
		100·076

Mr. T. Sterry Hunt, of the Geological Survey of Canada, has, under the title 'Contributions to Lithology,' given an exposition of the theoretical considerations which he thinks should serve as a basis to lithological studies. He has also pointed out desirable reforms in the classification and nomenclature of crystalline rocks.

Dr. John Dean has published in the Smithsonian Contributions to Knowledge a beautifully illustrated memoir on 'The Gray Substance of the Medulla Oblongata and Trapezium.' The object has been to give the topography of those parts, with illustrations from a series of photographs made by himself. The photographs are of two kinds, on albumen paper and photo-lithographs. The former are only furnished for private distribution, but the latter are so well executed, that all the essential features are preserved. Photo-lithography has now advanced to a high degree of perfection; but in 1856, when Professor J. W. Draper was making the microscopic photographs, which his work on Human Physiology demanded, it was found necessary to copy them by hand on the wood.

REVIEWS.

METALLURGY.*

In all probability, the art of reducing Metals from their ores dates amongst the very earliest of the evidences, which we possess, of the exercise of human reason, in the infancy of mankind, upon the crude natural products of the Earth. The poets have imagined the discovery of the metals to have been accidental.

> "When shady woods, on lofty mountains grown,
> Felt scorching fires, whether from thunder thrown,
> Or else by man's design the flames arose,—
> Whatever 'twas that gave these flames their birth,
> Which burnt the towering trees and scorched the earth;
> Hot streams of silver, gold, and lead and brass;
> As Nature gave a hollow proper place,
> Descended down and formed a glittering mass." †

Accidents do not strictly belong to the advances of science. The same phenomenon may occur unnoticed for ages; but, eventually, a mind *prepared* to receive the truth, seizes the indication and gives it a practical value. Many strong objections could be urged to the poet's view; but since the story of Metallurgy is lost to history, the above tradition is as worthy of reception as any other.

The oldest records inform us that a considerable degree of perfection in the working of Metals had been acquired ere yet History had begun to keep her record. Job and Jeremiah use the refining of silver as symbolic of the condition of the people, by whom they were, each in his respective age, surrounded. Hesiod and Homer describe the precious metals, and especially notice the valuable applications of Bronze and Iron. Archæologists have, as it appears to us, somewhat hastily, made the divisions of a Stone age, a Bronze age, and an Iron age, to represent certain steps in the upward march of our race. That the use of Bronze should have preceded the use of Iron is not probable. That they were used at the same period, in the early days, is certain, since we have examples from Assyria of Bronze being cast upon cores of Iron.

Tubal Cain, "the instructor of every artificer in brass and iron," is curiously repeated by every nation as the one originator of these arts. The name varies with the people; but whether it be the Tubal of the Hebrews, or the Voelünd of the Scandinavians—the "Master Smith" is the one man who is worthy of "worship and honour."

* 'Metallurgy: The Art of Extracting Metals from their Ores, and adapting them to various Purposes of Manufacture.' By John Percy, M.D., F.R.S.
'Fuel, Fire-clays, Copper, Zinc, Brass. &c.,' vol. i.
'Iron and Steel,' vol. ii. Murray, London.

† 'Hesiod.' *See* 'Watson's Chemical Essays.'

However discovered, men must have used the simple metals before they employed the alloys. Nothing is more curious, in the history of human progress, than the fact, that the oldest tombs of Egypt, the buried palaces of Assyria, the "giants' graves" of Northern Europe, and the Celtic remains of our own Islands, yield Bronzes identical in their composition, and differing not from that which we now employ. Bronze is a mixture of Copper and Tin. Before these could have been combined, either in Egypt or Assyria, man must have obtained his Copper from the Peninsula of Sinai—and his Tin from the British Isles, or the Islands of the Indian Archipelago. Therefore, navigation must have advanced to that state which would have taught him to traverse wide and distant seas; and when the metals were obtained, experimental science must have determined the true proportions for making the best combination for implements or weapons.

The history of the Arts points to a much higher antiquity than that which we have hitherto been in the habit of assigning to the human family.

We have not to deal especially with the history of Metallurgy in considering the volumes which are before us, since they treat mainly of the practice of this Art. It was difficult, however, to resist the temptation of a few remarks on its antiquity, and the state of perfection at which it had arrived, at a very early period. To many, the mere smelting of the ore of a metal is a simple operation which an untrained mind could carry out. A glance at the two volumes on Metallurgy by Dr. Percy will show that every stage of reduction demands an amount of knowledge which can only be acquired by long-continued experiments, or close scientific study. By the latter the labours of the former may be much reduced, but never dispensed with.

England is the great metallurgical country of the world. Within her sea-girt Isles she possesses a greater variety, and a larger quantity, of the metalliferous minerals than are found in any other part of the Earth, within the same area. Gold and Silver—Copper—Tin—Lead—Iron—Zinc—Antimony—Cobalt—Nickel—Bismuth—and the ores of the rarer metals are found; and from one end of the land to the other, the blaze of the furnace proclaims the industry of her sons in reducing them to the metallic state. Tin smelting-houses in Cornwall; Copper works around Swansea; Zinc works in many places; Lead "smelt-mills" in the Northern Counties, North Wales, and other districts—and 562 Blast Furnaces in operation, proclaim the activity of our Metallurgies. Although we produce annually Metals and Coals to the value of 34,691,000*l.*, our literature has remained barren of Works treating of this subject. If we name some half-dozen on Metallurgy our list will be exhausted—and in no one of these is the subject treated with the desired comprehensiveness.*

* The following are the works alluded to:—

1. 'A Treatise on the Progressive Improvement and Present State of the Manufactures in Metal.' 2nd edition. Edited by Robert Hunt. 1853. Longmans, London.

2. 'A Manual of Metallurgy.' By John Arthur Phillips. Griffin, London.

3. 'The Useful Metals and their Alloys.' By Scoffern, Truran, Clay, Oxland, Fairbairn, and Aitkins. Houlston & Wright.

The 'Metallurgy' of Dr. Percy is published to meet a want which has long been felt, and which we rejoice to see, at last, adequately supplied. The two volumes which are completed (we think it wise to include both in our notice, although Vol. I. was published in 1861) embrace the most important Metallurgies, and they really leave but little to be desired. The author is peculiarly fitted by his education, and his opportunities, for the production of a work which must be equally acceptable to the manufacturer and the man of science.

To place an Ore of Lead—or Copper—or Iron in a fire, and by the intensity of heat to run out a fluid metal, is certainly a simple matter. But when we remember that nearly all ores are of a very compound nature; that the chemical affinities in action are of the most powerful kind; and that the metallurgist has so to direct his skilled labour, that a metal, as nearly pure as possible, may be the result, we shall be convinced that a considerable amount of scientific knowledge is required.

"As the word science in relation to a manufacturing art is often vaguely used, it may be well to give the following illustration of its meaning:—When an ore of copper, consisting essentially of copper, iron, sulphur, and silica, is subjected to a series of processes, such as heating with access of air under special conditions, melting, &c., copper is separated in the metallic state. The sum of these processes is termed the smelting of copper. In this operation of smelting, certain chemical changes take place: the sulphur combines with the oxygen of the air, and is evolved chiefly as sulphurous acid; the iron is similarly converted into oxide, which combines with the silica present to form a fusible compound or slag. There are thus several facts which are proved on chemical evidence. These facts, when systematically arranged, may be said to constitute the scientific knowledge of copper smelting: and that knowledge implies necessarily a knowledge of the chemical relations of copper, iron, sulphur, oxygen, and silica to each other. . . . The man who conducts the process of copper-smelting in ignorance of these facts, has simply an empirical, in contradistinction to a scientific, knowledge of the art." *

Dr. Percy's aim has been to give, in this work, clear technical descriptions of each process, and to explain by the light of science, the philosophy, if the word may be allowed, of every step. To do this, close and laborious study, at the furnace mouth, has been necessary, and this has been followed by a searching analysis of the products, in the quiet of a well-regulated laboratory.

This work is intended to convey the largest possible amount of information relating to the production of the Metals Nature gives us but two or three in a pure or *native* state, and, as it is designed with all things, the power of mind is necessary to mould them to a condition in which they become useful. Therefore, this work, very

4. 'Papers on Iron and Steel, Practical and Experimental.' By David Mushet. John Weale, London.

5. 'The Iron Manufacture of Great Britain, Theoretically and Practically Considered.' By William Truran, C.E. E. & F. N. Spon, London.

6. 'An Elementary Treatise on Iron Manufacture.' By Samuel Baldwyn Rogers. Simpkin, Marshall, & Co., London.

* 'Metallurgy:' Introduction.

logically commences with the *Physical Properties of the Metals*—and some *General Considerations on Metallurgical Processes*, proceeding to a full examination of *Fuel*, and then entering on the special Metallurgies of the useful Metals.

The development of Heat is necessarily a most important study to the Metallurgist. Heat of high degrees of intensity is required—and this must be produced with the utmost economy. The characteristics of various kinds of Fuel—such as Wood, Charcoal, Peat, Lignite or Brown Coal, Coal, Coke, and Anthracite, are therefore matters of interest. Hence Dr. Percy has devoted a large portion of his first volume to their consideration. We should be wanting in justice if we failed to state our high appreciation of the original matter,—experiments made with the most scrupulous care, and deductions drawn with philosophical acumen,—which marks this division of our author's labours.

That, notwithstanding all that has been written on the subject of Coal, and all the examinations to which this Fuel has been subjected by Chemist, Geologist, and Naturalist, we should be unable to answer the question, "What is Coal?" is a sad reflection on European philosophy. In 1853 a remarkable trial took place at Edinburgh before the Lord Justice General and a special jury to try this question. The result is well put by Dr. Percy:—

"At the trial there was a great array of scientific men, including chemists, botanists, geologists, and microscopists; and of practical gas engineers, coal-viewers, and others, there were not a few. On the one side it was maintained that the mineral was *coal*, and on the other that it was a *bituminous schist*. The evidence, as might be supposed, was most conflicting. The judge accordingly ignored the scientific evidence altogether, and summed up as follows:—'The question for you to consider is not one of motives, but what is this mineral? Was it coal in the language of those persons who deal and treat with that matter, and in the ordinary language of Scotland? *because to find a scientific definition of coal after what has been brought to light within the last five days, is out of the question.* But was it coal in the common use of that word, as it must be understood to be used in language that does not profess to be the purest science, but in the ordinary acceptation of business transactions reduced to writing? Was it coal in that sense? That is the question for you to solve.' The jury found it was coal. Since this trial the same mineral has been pronounced *not to be coal* by the authorities of Prussia, who accordingly have directed it not to be entered by the custom-house officers as coal." *

While these paragraphs are being written the question is again before the Courts. Evidence equally as conflicting as that given on the former trial has been tendered by the men of science on this. Judgment has again been given in the plaintiff's favour, and for the third time the Boghead mineral is decided to be *a coal*. This trial furnishes another example of the degradation of science, whenever its students are induced to use their ingenuity as Special Pleaders in a Court of Law. Dr. Percy says, "In the present state of science I do not believe it possible to propose an exact definition of the term coal."

* Vol. i. p. 78.

This confession shows the limited capacity of our language—the poverty of our knowledge—the uncertainty of our scientific definitions—and of the nomenclature of science when it advances—or rather attempts to advance—from mere details to enlarged generalities.

Naturally following the subject of Fuel, the Fire-clays and Crucibles come under notice, together with Sands, Sandstones, and all the natural refractory Minerals employed in the construction of Furnaces, and as the means of exposing the Ores to the action of intense heat. This section cannot but be of great value to the practical man. Not only have we the results of the labours of our best Chemists and Metallurgists given in concise and clear terms, but we have a considerable amount of original research communicating much that is important.

The Metallurgy of Copper has the first attention, and that of Zinc follows. There are few metallurgical processes which require so large an amount of chemical knowledge as Copper Smelting. Dr. Percy has carefully described every stage in the process, and, at the same time, explained the chemical changes which mark each stage. Nearly every condition of the furnace products in their passage from the ore to fine copper, has been submitted to the most searching examination in the author's laboratory. There is one feature in connection with this research, and indeed with all the original investigations included in these volumes, which must be recorded with unqualified praise. In no case has Dr. Percy avoided giving his own assistants the full merits due to their labours. In some instances indeed we feel that he may have overstated the claims of those who have worked merely under his guidance.

The history of Copper Smelting in Great Britain has evidently been a favourite subject of inquiry. It is therefore very complete. Not only have we full details of all the processes employed in this country—with drawings of the furnaces, &c., to scale, but we have accounts of Copper Smelting in Sikkim, Himalya, and other parts of India, in Japan, Sweden, Prussian Saxony, and Russia. It is quite impossible to do more than thus hastily notice these valuable contributions to applied science, which must be studied in the work itself by all who are desirous of obtaining accurate knowledge on the subject.

The History of Zinc Smelting is touched on, but it is not so satisfactorily given as that of Copper. Indeed the, in every way, interesting story of this Metallurgy in our own island is dismissed in a few lines. This is to be regretted, since the mining and smelting of Calamine—especially that which was raised in the Mendip Hills—was, in the time of Elizabeth, so important as to give rise to Acts of Parliament directed to prevent the Exportation of Zinc, mainly to compel "*Copper to be brought in* for the manufacture of Gun-metal, Bell-metal, Schrof-metal, Latten," &c., &c. Dr. Percy quotes much of the matter collected by Dr. Watson and Beckman, who dealt mainly with the ancient use of Zinc, and but little of interest besides.

The second volume of 934 pages is devoted to Iron and Steel. This is, without doubt, the most important division of Dr. Percy's labours. He has departed from the plan pursued by him in treating of Copper and Zinc. We have no special history introductory to the Manufactures of Iron and Steel, but a short sketch at the conclusion of the work. Much, it is true, will be found in the descriptions of the various processes, which is, in fact, their history. Still, we should have been pleased, as we believe many others would also have been, had the author devoted as much research to the History of the Metallurgy of Iron and Steel as he has done to that of Copper.

The Physical and Chemical properties of Iron are most ably dealt with, and every problem of interest in connection with the production of this valuable metal is carefully examined. The different states of *grey iron*, *white iron*, and *mottled iron* have been subjects of close investigation. Dr. Percy gives us his own researches into the modes of existence of Carbon in Iron on which these states depend, and also some account of every inquiry of any value which has been made by British or by Continental Chemists and Metallurgists.

Spiegeleisen, or specular cast-iron, which is now a product of the highest importance to the Iron and Steel manufacturer, has, of course, claimed a considerable share of Dr. Percy's attention. He clearly refers the peculiarity of this metal to the Manganese, which he finds in combination. Yet, he states sufficiently all the evidence which has been adduced to prove Spiegeleisen to be a definite compound of Carbon and Iron, the Manganese playing an unimportant part.

All the great questions of the combination of Silicon, Phosphorus, Sulphur, Titanium, and Tungsten with Iron or Steel are carefully examined, and this section of the work deserves the most careful attention of every Iron master. The numerous alloys of Iron are described, and most of the patent inventions (?) connected with this much disputed question, of the merit or demerit of alloying Iron or Steel with other metals, have a large share of attention.

The analyses of British Iron Ores is exceedingly complete. In 1851 Mr. S. H. Blackwell collected with much care, industry, and cost, examples of the ores then known. These were displayed by that gentleman in the Great Exhibition, and a very careful description of them, by him, will be found in the large catalogue of that Exhibition. This collection was given by Mr. Blackwell to the Museum of Practical Geology, and with it the sum of 500*l* "towards defraying the cost of analyzing all the more important of those ores." Analyses have been made in Dr. Percy's Laboratory of a very large number of these ores, and published, with descriptions of their modes of occurrence, at the expense of the Government.* The collected analyses, therefore, given in this work, are of the most trustworthy and complete character. The processes of smelting Iron in all parts of the world are described. We believe we may safely say that the author gives descriptions of every variety of Iron Furnace in use, and in nearly every case, the accompanying drawings are to scale. The sections of the English Blast Furnace which are given, are remarkable examples of the amount of care which has attended every stage of the

* 'Memoirs of the Geological Survey of Great Britain: The Iron Ores of Great Britain, parts 1, 2, 3, 4.' Longman & Co. London.

inquiry into this important division of Iron manufacture, and of the zeal with which author and engraver have laboured to produce the most satisfactory results. With the enormous development of our Iron industries, there has been, naturally, greatly increased attention to all the details of manufacture. Every stage of the process, from the casting of "mine" (iron ore) into the furnace, to the flowing out of pig-iron, has been rigorously investigated by the author; and, again, every step in the progress of manufacture, into "merchant bars," or the conversion of iron into steel, has been subjected to the most minute examination. The attention which has been given by Dr. Percy to all these points has ensured a great degree of exactness in his descriptions, and there is little left to be desired in any one of them.

The invention of "Puddling" by Henry Cort is now very satisfactorily established; and the story of his ruin, through the fraudulent conduct of his partner, Mr. Samuel Jellicoe, and the stupidity and blundering of the government officials with whom he had to deal, is stated by Dr. Percy with great lucidity, and with the most honourable and kindly feeling. We should perhaps explain, for the benefit of some of our readers, that "puddling" is a name given to a process by which *pig-iron*, molten on the bed of a reverberatory furnace heated by flame, is converted into *malleable iron* through the decarbonizing action of the oxygen of the air circulating through such a furnace. Pig-iron is, essentially, a compound of Carbon and Iron: other matters are combined with, and influence its quality, such as Sulphur, Silicon, Manganese, and Phosphorus. These are removed either by combination with oxygen when they escape in the gaseous form, or by mixing with the slag, when they are mechanically removed. The mean of many analyses of Pig-iron gives about 3 per cent. of Carbon, $2\frac{1}{2}$ per cent. of Silicon, and 94 of Iron; that of Malleable Iron being about $\frac{1}{4}$ of a percentage of Carbon, and $\frac{1}{8}$ of Silicon. This is to be considered as a general statement of the character of these two varieties of iron, the difference it will be seen depending upon the absence of Carbon or Silicon. Many processes have been devised to supersede the laborious operations of puddling, but none of them have been as yet entirely successful.

Steel is a third condition of Iron, in which some Carbon exists in a peculiar state of chemical combination with the Iron. Dr. Percy says:—

"The production of Cast-iron into Steel by partial decarburization may be effected in several ways: and of these are three of chief importance, namely, fining in a hearth with charcoal as the fuel, puddling in the reverberatory furnace, and the Bessemer process. The first is the ancient method, which is still extensively practised on the Continent, especially in Styria; the second is only of recent date, but has, nevertheless, made rapid progress; and the third is the most novel, and certainly destined to play an important part in the world. If Steel be regarded simply as Iron carburized in degrees intermediate between Malleable and Cast-iron, then it is obvious that the latter, during its conversion into the former in the process of fining and puddling, must pass through the state of Steel. Accordingly, it is found that by suitably regulating and arresting the decarburizing action in these processes, Steel may be obtained instead of Malleable Iron."

The "Finery" process as practised over Europe is very satisfactorily described, and, as far as we are acquainted with it, the same may be said of the descriptions given of the production of Steel by puddling. The "Section on Decarburization by blowing atmospheric air through molten pig-iron," admitted by Dr. Percy to be a process "*destined to play an important part in the world*," does not strike us as being so complete as is desired. This is the Bessemer process, which consists essentially in placing molten pig-iron in a vessel called a "converter"—an ellipsoidal vessel, made of wrought-iron,—and then forcing, by blowing engines, a blast of air through it. Dr. Percy says of this process:—

> "I never witnessed any metallurgical process more startling or impressive. After the blast was turned on, all proceeded quietly for a time, when a volcano-like eruption of flames and sparks suddenly occurred, and bright red-hot scoriæ or cinders were forcibly ejected, which would have inflicted serious injury on any unhappy bystanders whom they might perchance have struck. After a few minutes all was again tranquil, and the molten malleable iron was tapped off."

By the action of the atmospheric air on the molten pig-iron, a temperature is obtained, higher than any ever before attained in metallurgical operations. This process is now in active operation in some of the largest works in this country, and others are engaged in adapting their works to receive the required machinery. In Sweden, Prussia, and France, the Bessemer process is superseding every other, and it promises indeed, as Dr. Percy says, "to play an important part in the world."

This invention was clearly arrived at by persevering industry, and an irrepressible hope which led the inventor to pass by failures as things of course, and steadily to work to the end which he has achieved, and for which he is now receiving a substantial reward.

We hope, in the second edition of this work, that Dr. Percy will give us the benefit of such a close examination of every stage of the Bessemer process as its high, admitted, importance demands, and which he has given to some of the other processes described by him.

We cannot refrain from expressing our regret that one feature, so strongly marked as to become a peculiarity, runs through this work. We allude to the desire, almost always shown, to trace back each man's thought to some often undeveloped thought of earlier and yet earlier date. The analytical character of Dr. Percy's mind has, to a great extent, led to this. The kindly spirit with which he reviews the history of the discoveries made by Henry Cort is a most pleasing exception to his rule. What the poet Coleridge said of those critics who were always endeavouring to find yet earlier footsteps in the snows of Helicon, in which the last adventurers on the hill of Fame had trodden, applies with equal force to the historian of science or of manufacture. We do not for one moment intend to dispute the correctness of any one of the statements made regarding early or foreign processes, nor do we intend to say that they are not in many respects like those more modern processes with which they are compared. But in every instance where success has attended the recent process, it will be found to be due to some original thought, which renders the manipulatory details on which that success depends, an original discovery. Do not let us encourage the habit of endeavouring to diminish the small rewards, which, in the aggregate, are gained by inventors. In some few cases a substantial recompense for benefits gained is bestowed by the public on the originator of a novelty, but in by far the larger number, the sole reward is the consciousness that success has been deserved, although it has not been achieved.

There cannot be any difference of opinion, amongst those who are acquainted with Metallurgy, on the value of this work, as elucidating nearly every point of importance in the processes by which the ores are converted into metals. The man of practice may possibly think it would have given a more complete character to the work if the author had minutely dealt with the numerous phenomena which present themselves to the smelter. The man of science may feel that he desires on many points, an examination yet more searching than that which Dr. Percy has given. To the first we may reply that the minuteness desired by him would have detracted from the use of this work. It deals sufficiently with all the principal changes, chemical or physical, which are essential to the production of marketable metal. The minute details if described in a book, cannot be learnt from it, and therefore only tend to obscure the more important matters.

To the latter, we say, for special examinations you must go to special treatises, and remember that Dr. Percy has in nearly every instance indicated the sources from which he has drawn his facts, and from which the additional evidences can be obtained.

"METALLURGY" is a most valuable contribution to the Literature of Science and the Arts. It removes from us the censure that we did not possess a treatise on the metals, of any standard character, and it gives us a work to which we can with satisfaction refer, as setting forth in clear and intelligible language all that it is necessary to know of the processes employed in our large works, to give those results which have placed us as the first Metal-makers in the world.

We cannot conclude our notice without speaking of the numerous woodcuts which add greatly to the value of the book. In execution they are superior to any that can be found in our works on Science. The precision with which they have been copied, and the clearness with which the minute parts have been engraved, constitute them examples to all wood engravers who may have to deal with Mechanics or Engineering. The scale which accompanies each engraving adds greatly to its value, since this renders it easy to construct a machine or build a furnace without any other drawings.

The author, and all who have aided in the production of this work, merit the utmost reward which an appreciating public can bestow on a careful record of the most important of British industries.

COMPARATIVE ANATOMY AND CLASSIFICATION.*

One of the most striking qualities of the human mind is the perception of the order which pervades the universe; and one of its most remarkable tendencies is to arrange and classify all visible objects and perceptible forces. It matters not whether the objects are vast and distant, as the heavenly bodies; near and appreciable to the touch, as the constituent parts of the earth or the living objects on its surface; whether visible to the eye, as organic and inorganic beings of definite form and colour, or cognizable only through chemical or physical agencies, as gases, &c.; it is immaterial whether the forces be physical, as magnetism, electricity, light and heat, or vital, such as those which are especially manifested in plants and animals, or, lastly, even the phenomena of the human mind itself; the habit of man is always to deal with these various objects and powers in an orderly, systematic manner. And if this systematic or classificatory treatment were simply applied to such objects as minister to his own wants and desires, to plants, animals, useful or ornamental minerals and so forth, one might be disposed to regard this quality of the mind as an instinct analogous in some degree to the power of selection for utilitarian purposes possessed by some of the lower animals. But we find the very reverse to be the case; namely, that individuals and races of men who appear to have no higher aim than to satisfy their bodily wants, care little about the order or arrangement of the things which surround them, whilst men of the highest intellects (those, indeed. who often think the least about the practical uses of the objects that engage their attention) have from time immemorial been employed in detecting relations in natural objects, and in drawing up systems of classifications to embrace all forms having characteristic features in common, whether in the organic or inorganic realm of nature.

That such systems of grouping or classification are chiefly, if not entirely, the creations of the human intellect, few will be disposed to doubt who have perused the past history of any branch of science, and it is obvious that like many other aids to education, they have been invented for the purpose of facilitating the acquisition of knowledge. Were man acquainted, for instance, with the form, structure, and vital attributes of all living and fossil animals, he would not conceive of the animal kingdom as parcelled out into sub-kingdoms, classes, orders, families, &c., but it would present itself to his mind as one perfect connected whole; and if for the convenience of reference, it pleased him to retain these old boundaries, it would only be as he now rules the meridians upon his maps; for they would no more have a real existence than have the lines of latitude and longtiude upon the surface of the globe.

Another curious phenomenon in connection with this faculty of

* 'Lectures on the Elements of Comparative Anatomy,' by Thomas Henry Huxley, F.R.S., Professor of Natural History, Royal School of Mines, &c; 'On the Classification of Animals, and on the Vertebrate Skull.' John Churchill & Sons, 1864.

classification, is that it has a value apart from the knowledge of the objects of which it treats. As this is a somewhat vague expression, we would explain it by saying, that the knowledge how to classify is *one* science, whilst an intimate acquaintance with the subjects classified is *another;* it is not at all unusual to find a clever systematiser who has little intimate practical knowledge of the large majority of objects which he arranges according to their leading properties, whilst there are innumerable so-called practical men of science to whom systems of classification are almost unknown. When, however, we meet with an individual proficient in both departments of knowledge, it may naturally be expected that any new arrangements proposed by such an one, will be valuable to students and observers. In no branch of science have there been greater changes in regard to classification than in natural history; and when we restrict that term to its popular signification, zoology, we cannot fail to be struck with the great number of systems which have from time to time been recommended by men of undoubted eminence, subjected to alterations, corrections, and emendations, and which have superseded one another with astonishing rapidity. To the young beginner this circumstance is often a matter of great perplexity, and he frequently finds that when at the recommendation of a friend or teacher, having a particular bias, he has mastered the arrangement of some well-known systematic zoologist, he has a great deal to unlearn, before he can renew his studies on a par with those who have availed themselves of more recent, or perhaps more accurate systems of classification.

Some years ago, a favourite book with beginners was Rymer Jones's 'Natural History of Animals,'* a very attractive little work, well written, and beautifully illustrated, and one that has no doubt raised up many an active and useful devotee of science. The author of this book, believing all methods of classification propounded up to his time to have been very imperfect, set to work to build up a new one based upon the most recent experiences of his day. Aristotle, he told his readers, had simply classed all animals under two great heads, the one possessing colourless, and the other red blood, divisions which correspond with the *invertebrata* and *vertebrata.* Passing from the old Greek philosopher to the fathers of modern zoological science, he touched upon the systems of Linnæus and Cuvier, both of whom, recognizing in the structural peculiarities of animals suitable guides for classification (the external horny cases in insects, or the internal bony framework of the *vertebrata*, for example), based their arrangements upon these characteristics. But because the author could not find in them squares ready fitted to receive some of the more recently discovered forms of life, he was dissatisfied with both these systems, and regretting that the celebrated John Hunter had not lived long enough to carry out *his* physiological views in regard to classification (inasmuch as that great anatomist had obtained "an indistinct glimpse of the clue that would have served to guide him"), he announced that the researches of modern physiologists had "fortunately left us in no doubt upon the

* Van Voorst, 1845.

important question," for that the essence of all physiology points to the nervous system as the basis of all correct arrangements, and upon the presence, absence, or supposed characters of that system, he (the author) therefore based his classification. But supported as he was in this view by many men of the highest eminence, he soon found himself in the same dilemma in which he had placed Cuvier, the greatest systematic zoologist of the age; and in a work published some years afterwards,* he himself acknowledged the imperfection of his "neural" system of classification, and stated that "in the lower forms of the animal kingdom especially, we are far from being able to avail ourselves of such a guide." He did not venture, however, to substitute a better system, but employed the old one as a *pis aller*.

In referring to this fact, we by no means seek to disparage the author's labours in the cause of science; on the contrary, we consider that the acknowledgment of the imperfection of his system redounds to his praise, and exhibits a moral courage not often possessed by scientific men.

Turning now to the Continent, we find two recent works on systematic zoology, both still regarded with great favour in scientific circles, and the authors of which have built their systems upon almost entirely dissimilar foundations. In his Guide to the Study of the Invertebrata,† Siebold has founded his classification upon the form and structure of animals, ranging them according to the simplicity or complexity of their organization, and availing himself of all known data of structure and development; whilst Vogt (whose work, with all its imperfections, is perhaps the best zoological handbook extant) ‡ has built up his system solely upon the phenomena of development.

Nor is it surprising that Vogt should have singled out these phenomena; and although we shall presently perceive that his system was as much open to objection as that of other naturalists who direct their chief attention to one phase only in animal existence, we cannot be surprised at his having selected this one, for at the time he undertook his task, every day was revealing new features in the development of animals which appeared to set at defiance all previous modes of classification. To speak popularly, Echinoderms were found, first, to lead the life of "Acalephs;" Medusæ, that of the hydra; winged insects gave birth to others without organs of flight, and these again produced offspring resembling their grandparents; creatures that swam freely about in the water appeared to become degraded, and to belong to quite a different class, as entozoa, when their old habitat was changed for the internal organ of some warm-blooded creatures: and thus it became as difficult to define the true position of a vast number of animals which, in various stages of their existence, changed their form and character, as it would be for an uneducated man to

* 'The General Structure of the Animal Kingdom.' Van Voorst.

† 'Lehrbuch der Vergleichenden Anatomie der wirbellosen Thiere,' by C. Th. V. Siebold, being the first volume of the 'Lehrbuch der Vergleichenden Anatomie,' by Siebold & Stannius. Berlin: Veit & Co., 1848.

‡ Zoologische Briefe: Naturgeschichte der lebenden und untergangenen Thiere." 2 vols. Frankfort am Main Literarische Anstalt. J. Ruetten, 1851.

decide whether a butterfly ought to be ranked as a worm or as an insect; and it was found necessary to raise this and degrade that form of life, according to the stage in which it had been observed when its place in the animal kingdom was first assigned to it. But Vogt was not content to rectify the boundaries of former systems, and fill up gaps that had been left open through the imperfect knowledge of those who preceded him. The phenomena of development had taken such complete possession of his mind, that he allowed them to serve as his chief guide in classification; and thus we have the whole animal kingdom divided, according to his method, into three great groups, each possessing, as he believed, some marked embryonic peculiarity, or, more correctly speaking, each having a distinct method of reproduction. The lowest of these groups, comprising the forms now known as *Protozoa*, had (according to Vogt) no true ova; the second, embracing the *Radiata*, *Vermes*, and all the *Mollusca*, except the *Cephalopoda* (cuttle-fishes, &c.), was the result of the transformation (or absorption) of the whole yolk into the embryo; and the highest group in which he found the embryo developed distinct from the yolk (Gegensatz zwischen Embryo und Dotter) comprised the *Cephalopoda*, *Articulata*, and *Vertebrata*. In like manner, he was guided in the subdivision of these groups, especially of the last-named, by certain features in the development of the embryo *in ovo*, or of the fœtus.

This system of classification was always considered faulty by the leading zoologists of Germany; and we need only state that the Infusoria, which he classed in his group possessing no ova (kein Ei), have, through the recent researches of Dr. Balbiani, of Paris, been shown to be sexual and to produce ova; and that he would be compelled to seek some other feature in their structure or development in order to define their true position, to show that his system is quite as imperfect as those based upon any other single phase in animal life.

But our limited space prevents us from referring to other systems of classification, and with a passing tribute to the great zoologist Milne-Edwards, the worthy disciple of the illustrious Cuvier, whose labours have been transferred, with or without acknowledgment, to innumerable so-called Hand-books and Text-books, which have been published in almost every European language, we must now direct the attention of our readers to the work before us.

The first portion of the treatise, which is a reprint of a series of Lectures delivered by the Author at the Royal College of Surgeons, is devoted solely to the subject of Classification, and to the relations of one group of animals with another. As a series of essays on this branch of zoological science, it is not only very valuable to students who already possess some knowledge of the subject, but will be found deeply interesting to more advanced readers, who have not had the opportunities afforded to the author of watching the progress of systematic zoology during the last few years, or to those whose studies have been directed rather to practical and experimental zoology than to the literature of the science.

As regards the author's system of classification, he tells us that it is based "upon purely structural considerations," and that animals have been regarded "not as related to other forms of life and to climatal conditions—not as successive tenants of the earth, but as fabrics, each of which is built upon a certain plan."

Availing himself of the Cuvierian classification, instead of aspiring to be the founder of a new method, he has built up the following improved zoological system :—

TABLE OF THE CLASSES OF THE ANIMAL KINGDOM.

The Limits of the Four Cuvierian Sub-Kingdoms are indicated by the Brackets and Dotted Line.

RADIATA.

Gregarinida. *Infusoria.*		*Scolecida* (?).	RADIATA.
Rhizopoda (?).		*Echinodermata.*	
Spongida.	RADIATA.		
		Annelida.	ARTICULATA.
Hydrozoa.		*Crustacea.*	
Actinozoa.		*Arachnida.*	
		Myriapoda.	
Polyzoa.		*Insecta.*	
Brachiopoda.	MOLLUSCA.		
Ascidioida.			
		Pisces.	VERTEBRATA.
Lamellibranchiata.		*Amphibia.*	
		Reptilia.	
Branchiogasteropoda.		*Aves.*	
Pulmogasteropoda.		*Mammalia.*	
Pteropoda.			
Cephalopoda.			

As each of the foregoing groups, the author says, "embraces one of the principal types or plans of modification of the animal form," a precise knowledge of that which constitutes the typical structure of each of these groups" will serve to convey an exhaustive knowledge of the animal kingdom. He proposes, therefore, to "define the various groups," or where definition is not yet possible, "to describe a typical example." And it is due to Professor Huxley to say, that in thus seeking to present to his readers a correct outline of the animal kingdom, he has fulfilled all the conditions essential for the execution of his task; and where he falls short in its performance (as he acknowledges from time to time, in the course of his survey), it is not from any inability to classify and arrange, but owing to the want of materials with which to operate.

His illustrations (we mean his drawings), which necessarily form a most important feature in the work, have the merit of being to a great extent original, and those which are not so, are in most cases taken from the newest works bearing upon the special subject to which they refer, the observer's name being in every instance appended to them,—a rule which we recommend for more general adoption. The careful dissections of the author, more especially of the typical examples *Phallusia*,* *Anodon*, *Helix*, and *Sepia*, are remarkably well adapted for displaying the organization of the groups to which they belong, and, in addition to a great number of typical illustrations taken from life, the student will find two little diagrams exhibiting, in a simple but striking manner, the distinctions between the general structure of the vertebrate and invertebrate types of the animal kingdom. In adopting, as he has done, the system of Cuvier, the author has displayed sound judgment, and, generally speaking, his additions and modifications, necessitated by the advances in zoological science, appear to be the best he could have made. We recommend this portion of his work to "science teachers," and to students who wish to base their knowledge upon a good foundation. For these purposes the language might have been simplified with advantage, but in no case is there a want of clearness, nor do we find in it any affectation of learning, although, as we have already said, the most important facts which have recently been contributed by the leading observers of the day, both at home and abroad, are included in his comprehensive review of the animal kingdom. To this retrospect the first six chapters of the work are exclusively devoted.

In our notice of those Lectures in Professor Huxley's work, in which the structure and development of the vertebrate skull and "the theory of the vertebrate cranium" are treated of, it is not our intention to attempt an analysis of the multitudinous details (many of which are of a most elaborate nature) therein discussed, but to confine ourselves to the consideration of some of the leading propositions laid down and conclusions arrived at.

Since the year 1807, when Oken, in his "Programm," first announced the remarkable hypothesis that the skull is but a peculiar modification of the vertebral column, the "vertebrate theory of the cranium" has more or less occupied the attention of many distinguished anatomists, and Spix, Bojanus, G. St. Hilaire, Carus, and Professor Owen, have published elaborate Memoirs, in which they have adopted the general conception of Oken, with more or less modification in the details of his plan.

The great reputation of the celebrated English anatomist, and the weight attached to his opinions, have induced many anatomists in this country to accept his views, without, perhaps, inquiring minutely into the data on which his conclusions are based. And in some of our anatomical text-books the nomenclature, and system of arrangement of the cranial bones into vertebræ, advocated by Owen, have been introduced, not without creating confusion, into the descriptions of the human cranium. There were, however, always a few anatomists who declined to give in their adhesion to the system of Professor Owen. Most prominent amongst these was Professor Goodsir, who, applying to the investigation of the subject the embryological researches of Von Baer, Rathke, Reichert, and Remak, pointed out, not only in his Lectures delivered in the University of Edinburgh,

* The description of this form, and perhaps of one or two more, is rendered somewhat obscure through an apparently incorrect lettering of the woodcut.

but more systematically in some highly philosophical Memoirs read before the British Association in Cheltenham, August, 1856,* the impossibility of reconciling many of the morphological conceptions of Owen with what is known of the mode of development of the cranium, and of its relations to the vascular and nervous systems. The necessity of combining embryological investigation with comparative anatomy in all our morphological inquiries was at once put on a firm and scientific basis by these Memoirs of Mr. Goodsir's.

In pursuing his investigations into the morphology of the skull, Mr. Huxley has employed both these methods of research, and has arrived at the conclusion "that the skull is no more a modified vertebral column, than the vertebral column is a modified skull: but the two are essentially separate and distinct modifications of one and the same structure, the primitive groove."

To make this proposition clear to our readers, it is necessary we should explain that one of the first indications of the development of the body of the vertebrate embryo is the appearance of an elongated linear groove in the blastodermic membrane, the anterior end of which, somewhat dilated, corresponds in position to the future head. At the bottom of this groove a cellular cylindrical rod, the notochord, is formed, which extends throughout the whole length of the future vertebral column. The anterior end of the notochord passes into the dilated cephalic end of the primitive groove, and corresponds in position to a part at least of the future basis cranii. Embryologists do not agree as to the distance to which this notochord passes forward in the base of the embryo skull. Mr. Huxley, grounding his statements mainly on the observations of Rathke, pronounces very positively that in all the vertebrata, Amphioxus only forming an apparent exception, it stops short immediately behind that part of the basis cranii which lodges the pituitary body.

Now, highly as everything should be valued which Rathke has written on developmental matters, yet it ought not to be forgotten that this position of his has not been allowed to pass unchallenged by embryologists of equal, and of almost equal repute. Thus Reichert, the eminent professor of anatomy in the University of Berlin, states that it passes at an early stage of development into the frontal region, and Kölliker also has observed it to reach farther forward than Rathke allows. In that very remarkable fish, the Amphioxus, in which the cranium remains membranous throughout life, the notochord extends almost to the anterior end of the head, far in front of the origins of the olfactory and optic nerves, and therefore beyond the region which would correspond to the pituitary fossa. The very striking exception which this fish affords to the universality of Rathke's proposition, may well make us pause and ask if our investigations into the mode of development of the vertebrate cranium were more extended than they have as yet been, might not other animals be found in which similarly well-marked exceptional arrangements exist?

From the sides of the "primitive groove" thin membranous

* Subsequently published in detailed abstract in the 'Edinburgh New Philosophical Journal,' January, 1857.

laminæ, "the dorsal laminæ," grow up, and gradually inclining inwards coalesce by their edges in the middle line. They form the foundations of the lateral walls of the skull and spinal column, and they assist in enclosing the spaces known as the cranial cavity and spinal canal.

The notochord then becomes surrounded in its whole length by a gelatinous investing mass which gives off anteriorly two bands, the "trabecula cranii." These are prolonged forwards, and, according to Rathke, embrace the pituitary fossa, and extend as far as the region in which the ethmoid bone is subsequently developed. Cartilage is then formed in this investing mass in by far the greatest majority of crania, and this constitutes the cartilaginous base of the skull and the bodies of the different spinal vertebræ. Mr. Huxley strongly insists on the essential difference in the mode in which this chondrification of the investing mass takes place in connection with that part of the notochord which corresponds to the spinal column, and that which lies in the basis cranii. In the former, he states a separate nodule of cartilage is developed for each of the bodies of the future vertebræ, whilst in the latter a continuous bar of cartilage is formed which never exhibits any transverse division or segmentation. And with this difference in the mode of chondrification he considers that the skull and spine at once begin to diverge from each other in their mode of development, each putting on its own special characters, each pursuing its own road to its final construction. But we may here pause and ask, are our inquiries into the "history of development" so far advanced—established on so sound a basis—as to permit us to accept, as unconditionally as Mr. Huxley would wish us to do, the primary continuous nature of the cartilaginous bar in the basis cranii developed in the investing mass of the notochord? Is its non-segmented nature to be looked upon as an ultimate fact in development? For our own parts, we doubt much if the subject as yet admits of so sweeping a conclusion to be drawn. But if we put altogether on one side these doubts which we have just raised, and accept the statement as a fact in development, what value are we to attach to it as an indication that, at this stage, the skull and spinal column diverge so strongly from each other that the one can be no longer regarded as a modified form of the other? Is it altogether to outweigh the generally admitted fact that the most perfect of all the forms of skull, *viz.* the osseous cranium, exhibits, like the spinal column, in advanced stages of its formation, undoubted evidence of segmentation, and in the primordial cranium it may be assumed that this segmentation is at least potentially indicated? And in the construction and arrangement of certain, at least, of these segments, there is an approximation to the plan of vertebral conformation, more especially in their central and neural elements, which at once appeals to the eye of the anatomist.

That the skull in its completely ossified state assumes a very definite segmentation is fully admitted by Mr. Huxley, and there runs throughout the lectures a very ingenious argument to show that in the whole series of osseous crania, from the pike to the man, three originally distinct segments may be traced. This concordance in the arrangement of the cranial bones, composing these segments, he considers, "places the doctrine of the unity of organization of the vertebrate skull upon a perfectly sure and stable footing;" whilst from the considerations already advanced, as to the non-segmentation of the cartilaginous bar in the basis cranii, "the hypothesis that the skull is in any sense a modification of vertebræ is clearly negatived." The three segments, which Mr. Huxley traces throughout the series, are the occipital, composed of the basi-, ex-, and supra-occipital bones; the parietal, of the basi- and ali-sphenoids and parietal bones; the frontal, of the pre- and orbito-sphenoid and frontal bones. These segments closely correspond with the central and neural portions of the occipital, parietal, and frontal vertebræ of Oken, Owen, and some other morphological anatomists. But we would ask, is it not possible to trace a still greater number of segments—whether we call them vertebræ or not, is of little consequence to this part of our argument —in the cranium? Mr. Huxley does not, in the above generalization, limit his segments to the region in which, or to the parts of the skull in relation to which, on his own showing, the notochord is confined. But, by accepting a presphenoidal segment, he admits of a cranial segmentation anterior to the pituitary fossa, *i.e.* in front of the spot where the notochord, as he contends, terminates anteriorly. Now, if the proposition be granted that the principle of cranial segmentation is not necessarily limited to the region of the notochord, but is applicable to the primordial cartilaginous cranium generally, we see no reason why, in those cases in which the structure and development of the skull admit of it, a still greater number of segments should not exist, ethmoid, vomerine, or even rhinal, as the case may be. We may illustrate this by a reference to the mammalian head. In the head of the mammal alone the nasal cavities are fully completed. And there enters, in a most important manner, into their formation, a series of cartilages, the nasal cartilages, which remain unossified. One of these, forming a part of the nasal septum, is the anterior prolongation of the basal portion of the primordial cranium, and ought therefore to be taken into consideration in coming to any conclusion as to the number and nature of the cranial segments. But the septal and lateral nasal cartilages, also, are quite passed over by Mr. Huxley, in his determination of the segments of the skull. Now this we cannot but think is a most important omission, and one, too, which, if supplied, might still more strongly serve to show, than has been done in these lectures, that, though there is in some respects a unity of plan in the cranial structure of the pike and the man, yet that there is in others "a no less marked diversity, each type exhibiting structures and combinations peculiar to itself." If the reception of a rhinal and a vomerine segment be objected to on the ground that they bear no relation to the neural axis, and differ in this, as in some other particulars, from the frontal, parietal, and occipital segments, it may be answered that at the caudal end of the spinal column great modifications in the form and composition of the vertebral segments often occur; modifications so great that the segment is often reduced to a mere centrum, and its correlation with the nervous axis completely lost.

Mr. Huxley has devoted much care and labour to the determination, throughout the vertebrate series, of the bones which are homologous to the petromastoid portion of the human temporal bone, and the mode of their development. Partly by a critical inquiry into the almost forgotten researches of Kerckringius and Cassebohn, and partly by the more recent observations of Meckel, Hallmann, and himself, he has shown that it ossifies from three distinct centres, to which he has given the convenient terms of pro-otic, opisthotic, and epiotic bones. These bones enclose the organ of hearing and "are very generally represented, sometimes in a distinct form, and sometimes coalesced with one another, or with other bones, throughout the series of skulls provided with cartilage bones; and the pro-otic especially is one of the most constant and easily identifiable bones throughout the series of vertebrate skulls."

He does not allocate these bones, either in their separate or conjunct capacity, to any of the cranial segments, but regards them, like the osseous chambers of the olfactory organs, as bony capsules interposed between the arches of the segments. Their true morphological position may, however, be still held to be an open question. For they are developed in cartilage which forms a fundamental part of the primordial cranium, and, as such, it may be and has been argued, both by Carus and Goodsir, that they should have a place amongst the cranial segments.

In studying the morphological relations of the inferior, or, as they are sometimes called, hæmal arches of the cranium, it is of great importance that the nasal cavities should be carefully examined and the position of the nostrils determined. Great weight was attached to these points by Mr. Goodsir, in one of the memoirs already referred to, and we find that Mr. Huxley has also carefully entered into the subject. It has now been satisfactorily determined that the posterior nostrils in the mammalia are openings of a totally different character from what are called the posterior nares in a bird, an amphibian, a snake or a lizard. In a man, for example, the nostrils open posteriorly behind the palate bone, whilst in the other animals named, they open in front of those bones, between them and the maxillæ, and cannot therefore be regarded as homologous apertures.

The nature of the mandibular and hyoidean arches, situated behind the orifice of the mouth, has always been a difficult problem for the morphological anatomist. The embryological researches of Rathke and Reichert have done much to clear up many of the obscure and complex questions involved in their investigation. Many sound morphological data were also furnished by Mr. Goodsir, both as to their relation to the cranial segments, and the homology of their constituent elements. With much that Mr. Huxley has written we are disposed to coincide, though we confess ourselves unable to accept all his propositions regarding these arches in the present somewhat uncertain state of our knowledge of their mode of development.

Although much has been done in these lectures to endeavour to supply an exact conception of the morphology of the vertebrate cranium, yet the author has evidently been unable to find a place for many of the bones existing there. We may mention, amongst others, the bones marked 1, 2, and 3, in the pike's skull, the supra-orbital and sub-orbital bones, and the transverse bone, the morphological position of which he leaves quite undetermined. Looking then at these and other residual quantities still unaccounted for, the anatomist cannot accept, nor do we think it is intended by Mr. Huxley that he should accept, many of the statements advanced in these lectures as furnishing a final settlement of that "much vexed question," the morphology of the cranium. There is much work yet to be done before we can hope to arrive at anything like a definite conclusion respecting it.

The lectures on the vertebrate cranium ought, however, to be read and carefully thought over by every anatomist, not merely because they record the opinions of so distinguished a teacher as Mr. Huxley, but because, from the singularly lucid way in which one of the most complex subjects in the whole range of anatomical science has been treated, they may well serve as a model to be studied by future writers.

We have felt justified in bestowing a large amount of space and consideration upon Professor Huxley's book (which should, in reality, have formed two distinct works), because we believe it will take a high place in the classical scientific literature of our country, and will be handed down to posterity as one of the most comprehensive treatises on some at least of the subjects with which it deals; but along with its valuable information, and excellent illustrations, it will also transmit the fact, too well known in our day, that its author entertains feelings of bitter hostility against his most eminent contemporary, Professor Owen, for there is hardly a chapter in the work in which these feelings are not manifested.

It is, no doubt, true (and is very much to be regretted), that in Professor Huxley's earlier days, and even more recently, he was pained by unfair criticisms upon his anatomical investigations, criticisms which were all the more ungenerous, because the object of them was then a young man struggling for a position amongst men of science; but is it any more creditable to retaliate upon his commentator, by characterizing his mistaken views as mendacious?

It matters little to us, whether or not the strife continues; and as far as the public are concerned, they either take it as a matter of course that Professor Owen will be attacked whenever Professor Huxley speaks or writes; or they crowd to the lecture hall with the same feelings as they would go to witness a prize fight; all we can say is, that it imparts to the non-scientific world a false estimate of the spirit which exists amongst scientific men, a very false estimate indeed, and what chiefly concerns us as reviewers is that it does great permanent injury and reduces the intrinsic value of an author's works, for it is difficult to accredit a writer with strict impartiality, who cannot exercise a little control over his feelings. These remarks are made in the most friendly spirit; and we hope shortly to have from the pen of the author a work of equal merit, without even this one serious defect. We have already spoken of the value of Professor Huxley's illustrations, and now conclude our notice with a word of praise to Mr. Wesley, the artist, for the excellent manner in which those illustrations have been transferred to the work itself.

ATHEISM AND SCIENCE.*

The extraordinary author of the extraordinary book before us says, quoting "Hirschel," that "nothing is so improbable but a German will find a theory for it," and he has favoured his readers with a most striking example of that truth in the publication of his own atheistical and materialistic theories, which are founded, as he believes, upon the newest discoveries of natural and physical science. We should certainly have allowed his book to run its course unheeded, without affording him an excuse for adding another to the four prefaces in which he defends himself against the attacks of his persecutors, were it not for another truth that it contains—namely, that "the scientific agitation in regard to the question discussed is daily spreading, and becoming, without exaggeration, a sign of the present time."

The inquiry is, indeed, spreading most rapidly, not strictly speaking as an "agitation," for those who agitate are for the most part men of limited knowledge and of no influence in society, and the bigotry of narrow theologians effectively prevents men of high eminence in science, who hold temperate philosophical views, from openly expressing their opinions. The effect is, that a substratum of materialism and atheism is silently forming beneath the visible surface of intelligent society, and such works as this, or others of a less offensive character, are the unhealthy eruptions whereby the disease is made manifest.

We give prominence to the present work in the hope, first, that it will awaken in teachers of religion an anxious desire to possess accurate information on all scientific subjects which have a bearing on theology, or where it is not possible for them to devote the necessary time to such a study, that they may be induced to seek the co-operation of talented *savans*, instead of regarding them with distrust, or driving them into open antagonism by stigmatizing their honest labours in the cause of truth as deeds of evil; and in the next place, we desire to show our intelligent men of science how necessary it is to be cautious in giving utterance to philosophical speculations which are liable to misconstruction, though they may appear to be based upon scientific data; and to satisfy them that the men who affect atheism are now, as heretofore, persons who possess indeed a larger amount of gene-

* 'Force and Matter.' Empirico-philosophical Studies, intelligibly rendered, &c. By Dr. Louis Büchner, President of the Medical Association of Hessen-Darmstadt, &c., &c. Edited from the last edition of 'Kraft und Stoff,' by J. Fredk. Collingwood, F.R.S.L., F.G.S. Trübner & Co.

ral knowledge than those whom they seek to pervert, and quite enough sophistry to turn what they do know to bad account; but whose theories will not bear a critical examination, and whose practice can hardly be expected to be such as would recommend them to honourable men, or even to justify their admission into respectable society.

We have deemed these prefatory observations necessary before acquainting our readers with the nature and contents of a work, the perusal of which has been a most painful task to us, although we are ever ready to listen to the theories of scientific sceptics, and to allow them a large share of liberty in their speculations.

The following is the philosophy of the author and of his school:—Matter and Force are both immortal. The forces are inherent, or immanent in matter; they are, in fact, properties of matter. Matter is infinite; it is "dignified," for "it is the vehicle of all mental power, of all human and earthly greatness."

The laws of nature are immutable and universal. "Spirit and nature are the same," and "reason and the laws of nature are identical."

The worlds were formed "from a shapeless mass of vapours by the rotary motion of specks, so as gradually to have become condensed into compact globular masses," and are kept in constant and regular motion by the law of attraction.

The idea of an "external personal" activity, or God, is excluded "by the many irregularities, contingencies, &c., in the economy of the universe and individual bodies." If there had been a personal creative power, "there would not have been these enormous waste useless spaces in which but here and there suns and planets swim, floating about as imperceptible points;" the moon would have had an atmosphere and water; the planets would have been all the same size; and, asks "Hudson Tuttle," an eminent atheistical authority, whose opinions are frequently quoted, but of whose writings we cannot help pleading ignorance beyond what we find in this book,* "Why did the Creator give rings to Saturn, which, surrounded by his eight moons, can have little need of them, whilst Mars is left in total darkness?" All changes in the Earth have been produced by ordinary known physical forces during enormous periods of time, and it would be absurd to suppose that an arbitrary Almighty power "should require such efforts to attain its objects."

When the Earth had cooled down from the state of a "fiery globe," and the watery vapours were precipitated upon it, then "organic life developed itself." In the lowest deposits in which organic forms could have existed, we find their traces, and they became developed with each ascending stratum, until in the uppermost man appears, "the climax of gradual development"—"Man is descended not from several, but from very many pairs."

There is no such thing (in the abstract) as design in nature, nor are there any traces of an active creating hand. Our reflecting reason

* It appears he published the 'History and Laws of Creation,' in 1860, but we are not told who and where is the publisher, or we might have included the work in this notice.

is the sole cause of the apparent design. "There is no natural contrivance which might not be imagined more perfect than it is;" the order which "appears to us as produced by design," "was established by natural conditions." "Nature has produced a number of beings and contrivances in which no design can be detected, and which are frequently more apt to disturb than to promote the natural order of things."* Very little has yet been done to show the use of such "troublesome and disgusting creatures" as "dangerous reptiles and insects."

It is a mistake to suppose that nature has done anything in anticipation of the advent of man, "there are no ends which nature had in view to favour a privileged being. Nature is an end in itself."

The brain is in all animals the seat and organ of thought. The two are inseparable, and the brain is proportioned in size, shape, and structure, to the magnitude of its intellectual functions. "Mental function is a peculiar manifestation of vital power, determined by the peculiar construction of cerebral matter."

The peculiar chemical constituents of the brain, and its complicated structure, account for the remarkable functions it performs. It is easy to prove that mind and brain are inseparable, for accidents to the brain cause a concomitant imperfection of the mind, and the entire removal of the brain leaves the body alive, but the soul is gone.

"Thought is a motion of matter," and the brain is "only the carrier and the source, or, rather, the *sole cause* of the spirit or thought. "The senses are the source of all truth and all error, and the human mind is a product of the change of matter."

The souls of brutes differ from those of men in quantity, not in quality. The term "instinct" is a misnomer, and all so-called instincts are the consequences of "deliberation, the result of comparisons and conclusions." The transition from the lower animals to man is imperceptible; the Crétin is *below* the brute, and the Negro has all the "characteristic peculiarities of the Ape."

Language is *not* a distinctive feature in Man. The lower animals can speak, some by signs, others by sounds, whilst there are whole races of men who are no better than animals in this respect, speaking more by signs than by articulate sounds. Educability is not peculiar to man; it is chiefly the difficulty of communication which prevents animals from rising in intelligence. The soul has no "personal continuance," for thought cannot exist without brain, and with the dispersion of the "force-endowed materials, and their entrance into other combinations, the effect which we call soul must disappear." This doctrine cannot be objected to on the ground that the "thought of eternal annihilation is revolting to the innermost feelings of man," for "the thought of an *eternal life* is more terrifying than the idea of eternal annihilation." Neither is there anything to be gained by a continuance of life.

* We cannot refrain from quoting here a sentence of the author's, from another part of the work (p. 251):—"Exact science inculcates modesty." This expression is, however, used in the chapter of "concluding observations," and perhaps it was a conclusion at which the author had not arrived at so early a stage of his investigations.

"Perfect truth would be a sentence of death for him who has acquired it, and he must perish in apathy and inactivity." The idea of a "Free Will" is based upon superficial observation of nature; if man have a free will, it is of the most limited kind. His will is dependent upon "a fixed necessity," upon climate; upon "intellectual individuality" which prescribes to him "his mode of action with such force that there remains to him but a minute space for free choice."

This is, we believe, the gist of the author's philosophy, and it cannot be denied that he not only possesses a large amount of superficial information, but that here and there he has displayed considerable tact in dovetailing it into his theories. Nevertheless, we cannot find that these are based upon the revelations of modern science, and furthermore, if the numerous contradictions and inconsistencies in which his work abounds, and of which examples will be given hereafter, and the confusion of ideas that may be found in almost every page may serve as our guide, we are justified in believing that the author is himself far from comprehending his own teaching.

Let us examine one or two of the fundamental principles on which his whole doctrine is based.

All the "so-called imponderables, such as light, heat, electricity, magnetism, &c., are neither more nor less than changes in the aggregate state of matter;" in other words, they are modes of motion; motion is, of course, a force, and "there is not a single case in which force" "can be born or annihilated." But motion, according to the author's views (in common with all force), is "immanent in matter;" "the motion of matter is as eternal as matter itself," and finally, the laws of heat, light, &c., are "everywhere the same."

Now, if we liked to dogmatize, we should be quite justified in saying that "*empirical*" knowledge teaches us that force is not immanent in, but always, as far as we can judge, external to matter, and that all conversions of force as well as changes in matter are performed by a governing will, and guided by a reflecting reason, notwithstanding the existence of apparent exceptions to this rule in nature. On a limited scale human reason and human will are constantly bringing about more or less important changes of this kind, and we have the author's precedent for holding that we have "not merely the right but the duty, in accordance with the laws of induction, to infer the unknown from the known, and to maintain that a universal law which is true for a portion of organic phenomena is applicable to all." *

However, we will not be so ungenerous as to turn the author's weapons against himself and assume to be his teacher; we will rather sit meekly at his feet, and be attentive listeners and learners. Let us hear how his "matter" and its "immanent forces" have comported themselves from eternity.

Matter, then, began its operations "by the rotary motion of specks," and all the modifications of motion which subsequently ensued are "merely the result of a single universal law of nature—*the law of attraction.*"† "Why matter assumed a definite motion at a

* P. 221. † P. 51.

definite time, is as yet unknown to us," but it is probable that the investigations of science will give us a clue to this mystery.*

It may be evidence of great obtuseness on our part, but we confess that the author travels too fast for us, for we cannot understand how, if matter be eternal, and motion, which is inseparably united to it, be eternal also, matter can ever have *begun* to move; and how it is that the "law" of attraction was not always at work. According to the author's views, "matter and force" must have had the power within themselves to commence a series of operations which have resulted in the formation of the worlds, and when they made up their mind to start, they did so; but we should be sorry to press even this moderate approach to a theological creed, because "we should approach to pantheistic ideas," which the author places in the same category with the vain fancies of believers in a Deity. †

However, granted that eternal matter with its immanent eternal forces, and controlled by the law of attraction, *did* "begin" to bestir itself, what followed? The inorganic world developed itself, and all went on smoothly until it was necessary for nature's ends (by the way, nature has no ends, "it is an end in itself"—for the development of matter, then) that organic life should appear. How was this brought about? Well, when the "fiery globe" was cooled down, and the vapours had settled upon the Earth "with the appearance of water, and as soon as the temperature permitted it, organic life developed itself."

And why not? "Where air, heat, and moisture combine, there appears sometimes in a few moments an innumerable world of singularly-shaped animals, which we term infusoria."‡ This is what is called "spontaneous generation," which "signifies the production of organic beings without previously existing homogeneous parents or germs, merely by the accidental or necessary concurrence of inorganic elements and natural forces," &c.§

And now we have presented to us evidences not only of the author's candid and impartial mode of inquiry, but also of the profundity of his research, and of the originality of his views.

"*Generatio æquivoca*" is not yet quite a settled question; Pouchet and Pasteur, Wyman, Jolly, Musset, and a crowd of investigators are still actively engaged upon the inquiry, but sufficient is ascertained to satisfy the author that this kind of generation "does not exactly possess a scientific basis," and that "*omne vivum ex ovo*" is becoming the order of the day. Let not this crude, unsettled state of science, however, afford any encouragement to believers in a Deity and a creation. "We might answer these believers, that the germs of all beings had from all eternity existed in universal space, or in the chaotic vapours from which the Earth was formed; and these germs, deposited upon the Earth, have there and then become developed, according to external necessary conditions. The facts of these successive organic generations would thus be sufficiently explained."||

There, reader, that *is* a theory founded upon "a scientific basis."

* P. 53. † P. 87. ‡ P. 66. § P. 69. || P. 71.

Some over-curious spirits might, perhaps, inquire what could have been going on in the "chaotic vapours" to produce these germs before their "specks" began to rotate, but that would be hypercritical, and we feel sure that all naturalists will be grateful to Dr. Büchner for this lucid exposition of his views concerning the origin of living organisms, more especially the advocates of spontaneous generation, the believers in the creation of foraminifera from "ooze," and in the spontaneous development of the gigantic reptiles of old, from the muddy beds of rivers, a theory which, by the way, appears to have the author' s valuable but qualified support.* And now, organic life being once established, development proceeds actively. It is, "perhaps, morally certain that a spontaneous generation exists, and that higher forms have gradually and slowly become developed from previously existing lower forms, always determined by the state of the earth, but without the immediate influence of a higher power."†

Here, too, a little difficulty presents itself. The revelations of science are certainly tending in the direction here indicated (leaving out the question of the higher power); but still the author feels that he would appear ignorant in the eyes of men of science if he did not acknowledge that the question is not yet *quite* decided; so he reminds his readers that external influences upon animals are, "though considerable, yet insufficient to change their specific form." The alternation of generations, the metamorphoses of insects, are evidences which may be adduced in favour of his theory; but even these phenomena, although they represent "a real change of the species," are limited. There has, however, been "one important and pregnant discovery" which should suffice to convince the most sceptical. It was made, not by an unknown observer, but by one of the greatest physiologists of the day; not by a sceptic, but by a "believer," and it was "a discovery which staggered its orthodox discoverer."‡ Johannes Müller discovered "a generation of snails in *Holothuriæ*," and "*Holothuriæ* and snails belong to different divisions in the Animal Kingdom." This discovery "removes any doubt as to the possibility of a permanent development of one species from a different one."

This is the kind of *canards* upon which the author bases his views as to the processes by which nature, as we now see it, has, "without the immediate influence of a higher power," called itself into existence, or, to speak more correctly, developed itself from vaporous masses; and we shall now cull from his book a few of his thoughts regarding the behaviour of nature whilst engaged upon its important task, so that we may be enabled to judge whether or not the intervention of any "higher power" was necessary for the perfection of the universe. But as our space is limited, and our criticisms upon this contribution to our scientific literature, however remarkable it may be, cannot be allowed to extend to an unreasonable length, we will at the same time extract a few of the author's ideas on other difficult subjects, and our readers will have an opportunity of judging how clear is the conception he has formed of them himself, and what deference he pays to truth and reason.

* P. 77. † P. 72. ‡ P. 80.

"Empirical natural science," he tells us, "has no other object than to find out the truth, be it according to human notions, consolatory or the reverse, beautiful or ugly, logical or illogical, rational or absurd, necessary or contingent."—(Cotta.) *

This statement, with which the work closes, may possibly perplex some of our readers. Indeed, they may be disposed to wonder what other "notions" an atheist, a man "who considers transcendentalism an aberration of the human mind,"† can have of truth, excepting *human* notions, or how truth can be truth, if it be illogical or absurd; but this arises from their not fully comprehending the wisdom of the acts of "Natural Science." They shall now be enlightened.

"Nature is perfect in itself, being in its development governed by unalterable laws." (p. 88, Prof. Giebel, of Halle.)

"We find in the constant harmony of nature a sufficient proof in favour of the immutability of its laws." (p. 33, Tuttle.)

As "Nature does not act from a conscious design, but according to an immanent necessary instinct, it becomes obvious that it must be guilty of many purposeless absurdities." (p. 94.)

"Nature has produced a number of beings and contrivances in which no designs can be detected, and which are frequently more apt to disturb than to promote the natural order of things." (!) (p. 94.)

This will convey to our readers some idea of the author's "nature." Another word concerning his "matter and force."

"Matter must have existed from eternity, and must last for ever." (p. 12.)

"Force is a mere property of matter." (p. 4.)

"There exists a phrase, repeated *ad nauseam*, of mortal body and immortal spirit. A closer examination causes us with more truth to reverse the sentence." (p. 13.)

"Although the immortality of matter is now an established truth, the same cannot be said in regard to force." (p. 17.)

This seems a little contradictory; however, let us search a little further, that we may be enlightened.

"No force can arise from nothing." (p. 2., Liebig.) ‡

"Indestructible, imperishable, and immortal as matter, is also its immanent force. Intimately united to matter, force revolves in the same never-ending cycle, and emerges from any form in the same quantity as it entered." (p. 16.)

"No motion in nature proceeds from, or passes into, nothing." (p. 17.)

"Physics show that, as there was a time when no organic life existed on earth, so will the time arrive—no doubt an infinite and incommensurable period—when the physical forces now existing will be exhausted, and all animated beings plunged into night and death." (p. 105.)

* P. 258. † P. 253.

‡ The names of Liebig, Helmholtz, &c., will be found in this work, as observers from whom quotations are made in support of the author's views; but in justice to these great and honourable men, we deem it right to say that isolated expressions are perverted in their meaning, just as dishonest publishers sometimes revenge themselves upon critics, by snatching from their adverse reviews portions of sentences apparently laudatory.

Let us supply or rather bring down the corollary :—

"Force is a mere property of matter," and "indestructible, imperishable, and immortal, as matter is also its immanent force" (until it is exhausted, we presume).

And how is the universe governed ?

"The same materials and the same laws govern the visible universe," and "everywhere act in the same manner as in our proximity." (p 45.)

"The laws according to which nature acts and matter moves, now destroying, now rebuilding, and thus producing the most varied organic and inorganic forms, are *eternal* and *unalterable.*" (p. 33.)

"There exists neither chance nor miracle, there exist but phenomena governed by laws." (p. 38, Jouvencel.)

"It depends on an accident whether or not they (natural objects) will enter into existence." (p. 90.)

A word concerning "vital force," and voluntary motion :—

"Vital force cannot be appealed to; that is scientifically dead." (p. xxvii.)

"The motion of what is called vital force, is now rejected by exact observation." (p. 215.)

"Mental function is hence a peculiar manifestation of *vital power*, determined by the peculiar construction of cerebral matter." (p. 125.)

When the embryo of man moves in the womb ;

"These motions are involuntary, not determined by a mental act." (p. 159.)

But the mode in which "vibriones, microscopical animalcules of the smallest kind," of which a cubic line contains 4,000 millions; the mode in which these living atoms move, "leaves no doubt that they possess sensation and will." (p. 24.) (!)

Having shown (as he believes) that man has no "innate intuitions," the author proceeds to argue, that those who believe in a Deity on the ground that the idea is innate, have no foundation for their faith, and mentions some nations which are said not to have any conception of a God.

He also adduces as evidence that the "Indians in Oregon" have for their highest divinity "the wolf," which "seems, according to their descriptions, to be a hybrid of a divinity, and an animal;" * and that,

"Paul Kane describes the Indian Chinooks, like most red skins, to be without distinct religious sentiments. They ascribe everything to the Great Spirit; but this Great Spirit is, according to their ideas, a very vague being, and not the object of any worship." (p. 187.)

Weighty evidence against "innate intuitions," and "*the Existence of a Deity.*" There is more of the same kind in the same chapter.

Amongst his authorities for disbelieving in the immortality of the soul, are, "the celebrated Chaumette," who, during the French revolution, "erected in the cemeteries statues representing Sleep;" Lessing, who thought it must be a great "ennui" to live for ever; Danton;

* P. 185.

the Jews before the Babylonian exile (how the race must have degenerated according to the author's views!); Shakespeare, (!)* Pliny, Homer, Simonides, Seneca, Pomponatius, Frederick the Great (the predecessor of kings who rule by divine right!) and "the enlightened of all nations and times,"† amongst whom the "dogma of the immortality of the soul has ever had but few partisans." On this ground then, if on no other, Messrs. Büchner, Tuttle, and Co. may be added to the above authorities, and included amongst the "enlightened." But it appears from Preface No. IV. that some of the author's critics are not disposed to admit him into this rank of society, and that others go still further in their malignity, and have attempted to damage him in public opinion by casting suspicions upon his moral character.

Not knowing anything of his private character, we cannot, of course, express an opinion on so delicate a matter: but we will allow the author to state his ideas of morals and morality; ideas which we presume to be held by all of like professions with himself.

"Science has no concern with morals." (p. lxv.)

"The person of the investigator, and that of his moral convictions, have nought to do with his investigations."‡ (p. lxv.)

"Annihilation, non-existence, is perfect rest, painlessness, freedom from all tormenting impressions, and therefore not to be feared." (p. 205.)

"Free will, if it exist, can only have a limited range." (p. 239)

"Man is free, but his hands are bound; he cannot cross the limit placed by nature." (p. 245.)

"Another (person) § *inclines to conscientiousness; he is just in all his transactions, and may put a term to his existence if deprived of the possibility of fulfilling his obligations.*"

Very convenient doctrines these for persons whose "cerebral matter" happens to be endowed with propensities to indulge in vices which do not come within the pale of the law, and who "act according to their impulses or habits," as all men do, in the author's opinion! || No free will, and a kind of conscientiousness which causes men to put an end to themselves, and seek the haven of "perfect rest," and "freedom from all tormenting impressions," when they can't pay twenty shillings in the pound.

This is the morality of Atheists and Materialists!

That any human being endowed with reasoning faculties and possessed of a fair amount of information could have trusted himself to give utterance to such a tissue of contradictions and absurdities as are to be found in this book, and should attempt to pollute the scientific literature of his age with such trash as it contains, is explicable through the views which he entertains concerning a Deity; but whatever can have induced an Englishman, aspiring to a respectable position in the scientific world, a Fellow of the Geological Society, voluntarily to

* 195. "Thy best of rest is sleep,
And that thou oft provok'st; yet grossly fear'st
Thy death, which is no more!"

† 213. "*The Duke*," *in* '*Measure for Measure.*'

‡ This depends very much upon the notions which he has concerning *truth.*

§ We italicize these lines.

|| Quoting Auerbach, p. 244.

sit down and translate a book full of blasphemy, to give his sympathies to a writer who sneers at all that the mind of civilized man has held sacred, who perverts scientific truth, and drags through the mire such honoured names as Liebig, Lyell, Darwin, Faraday, Humboldt, Flourens, Schiller, Shakespeare, Lessing, and the Scriptures, levying black mail upon them in support of his atheistical views; how he dares to print his name on the title-page as the editor, is quite incomprehensible to us.

We cannot but commend Mr. Collingwood's prudence in not "always" subscribing to the "alleged facts" contained in the work, and to the "inferences drawn from these facts," but we by no means envy him the great "pleasure" which he experiences in introducing the work to English readers; and whilst we entirely disagree with him as to the desirability of its being "admitted to the rolls of English literature," we feel sure that all classes of scientific readers, from freethinkers (in the more restricted sense of the term) to orthodox theologians, will pronounce it a vulgar, blasphemous book, full of absurd contradictions, and presumptuous, unscrupulous assertions, published, with its numerous prefaces, with a view to create a sensation, and the only persons to whom it will give unfeigned satisfaction are the small semi-educated sect of men calling themselves "Naturalists," or "Secularists," who will no doubt use it, as Dr. Büchner has attempted, to abuse science.

To us, the author appears to have done his very worst for science and for himself. Judging from observation and experience (and "whoever rejects experience rejects human conception" *), we shall expect him at some future time to be a rabid theologian; one who, if he had been an Englishman, would be found lecturing on Redemption in some obscure tabernacle, "all seats free, and discussion invited;" and infusing into his religious discourses about as much reason as he has thrown into his atheism.

We have no desire to be severe or condemnatory in our epithets, and shall content ourselves with saying, that if the author is sincere, and has undertaken a scientific expedition, it has been another illustration of the old German saying:—

"Es ging ein Gaenschen uber's Meer,
Und kam als Gans auch wieder her."

"A gosling crossed the sea, and a goose it returned."

The advantages which may arise from the publication of the work were referred to in our introductory remarks, and it is unnecessary to repeat them; but the moral it teaches, is one of the wisest that ever a wise man uttered, and we earnestly commend it to the consideration of the author and translator, and to all who feel disposed to sympathize with their doctrines. It was Lord Bacon who said, "A little philosophy inclineth man's mind to atheism, but depth of philosophy bringeth men's minds to religion."

* P. 253.

THE MICROSCOPE.*

If there be a philosophical instrument before any other that has exercised a beneficial influence upon modern society, it is the Microscope. It has lent an impulse to the study of Natural History, of which the results have been more striking than any recorded previous to its invention; and through its employment, man's acquaintance with the laws and operations of nature has in a very brief period increased in a degree almost miraculous. It has taught him to observe with greater care; to calculate with more accuracy; has opened out new fields for the exercise of the mental faculties, raising the sense of wonder and admiration whilst at the same time it cultivated the reason. To the artist and poet it has offered new scenes and themes in Nature; and, in other walks of life, has employed thousands of busy hands and brains. In its simplest form the manufacturer carries it in his waistcoat-pocket to examine the texture of his fabrics, the seedsman to inspect his seeds, and so in many trades; whilst the more complicated instrument has become almost indispensable to the higher professions—the surgeon, physician, and analytical chemist having recourse almost daily to its defining powers. Indeed, there is hardly a home where, in one form or another, the magnifying lens is not to be found; scarcely a cultivated family circle in which at least one member does not avail himself of its use.

And how is it that even as a mere means of recreation, the microscope should have acquired a position in the homes of men which no other instrument has been able to command? The revelations of the Telescope are certainly far grander, and the performances of the Magic-lantern more amusing; and yet, for every one of these instruments, we may count in the houses of the intelligent classes at least twenty microscopes. It is because the last-named instrument brings us into nearer relations with that mysterious influence which we call Life—an influence which human curiosity has endeavoured from time immemorial to fathom, revealing to our gaze the hidden springs of vital action in living objects with which our acquaintance was previously but superficial; and exhibiting new scenes from animated nature, where we were before accustomed to believe only in the existence of inorganic substances influenced by physical forces. For a long period indeed, whilst the possession of a microscope was a privilege accorded only to a few professional men, and was often employed by these rather as a means to mystify than to enlighten, the doings of the microscopical world were regarded as being beyond the ken of ordinary mortals; and even within the last few months we were informed by a friend, who had deputed us to select a microscope for the use of his family, that his gentler half entertained conscientious scruples with respect to the ad-

* 'An Elementary Text-book of the Microscope; including a Description of the Methods of Preparing and Mounting Objects,' &c. By J. W. Griffith, M.D., F.L.S., M.R.C.P., conjoint author of the 'Micrographic Dictionary.' J Van Voorst.

'The Preparation and Mounting of Microscopic Objects.' By Thomas Davies. R. Hardwicke.

mission of such an instrument into her house, as she believed it was not the intention of the Creator that we should see the things it revealed, or He would have enabled us to do so with the naked eye!

It may be considered ungallant to criticize the views of a lady, but we cannot help saying that such a remark exhibits a great want of confidence in the Creator, who has not only enlightened us by means of the microscope on many obscure points in Natural History, instructed us how to detect that adulteration which, like a false balance, must be "abomination to the Lord," and enabled man to prolong the precious gift of life; but has taught us through this medium that His relations are as intimate with the minutest objects of His creation as with the highest; for, as the telescope has revealed to us His power in the distant worlds, so has the microscope proclaimed his goodness in the water-drop!

It is not surprising, then, that the numerous practical uses of the instrument, coupled with its efficacy as a means of educating the mind and of pleasing some of our highest intellectual tastes should have caused it to be regarded with such great favour, and should have led to its extended manufacture; and it *would* have been a matter of astonishment, if, with its increased fabrication and employment, the world had not been favoured with numerous works upon the principles and mode of its construction, and the methods of its application. This has followed as a matter of course, and each season produces a number of works of more or less merit, and tending in a greater or less degree to diffuse the love of microscopical studies.

Amongst the treatises for the use of advanced students, the foremost in rank are Dr. Carpenter's 'Manual,' and the 'Micrographic Dictionary' of Dr. Griffith (the author of one of the works about to be considered) and the late lamented Professor Henfrey. Many others of great merit might be added; but if we were asked to recommend an elementary text-book for a young beginner, or for the use of amateurs, we confess that we should have great difficulty in selecting one that might fairly be considered complete in itself.

Even in the present incipient stage of the science, it would be difficult to embrace all that is desirable in such a treatise. A few hints as to the selection of an instrument, with an account of its chief parts, and how they should be manipulated; directions for securing and mounting useful objects in the most approved manner; a clear description and systematic classification of easily-attainable objects in the inorganic and organic realms of nature, to lead the young student unconsciously from "philosophy in sport" to "science in earnest," and cause a pleasant diversion to become the foundation of a lifelong study,—these are the desiderata in an elementary text-book; and such a treatise, we believe, has yet to be composed.

But, although it is by no means perfect, the one before us, written by the surviving author of the 'Micrographic Dictionary,' commends itself strongly to our favourable notice. It bears the impress of thoughtful care, extended knowledge, and a thorough acquaintance with the subjects of which it treats. Its contents are scientifically arranged, and the reader is made conversant with the elements of every branch of Natural History from which the illustrations are drawn; indeed, as far as it goes, it is admirably written, and we feel sure that every large-minded microscopical writer or observer will agree with us, when we pronounce Dr. Griffith's little work the best of the kind extant. Its chief merit consists in its truly educational character, which raises it above many of those brochures whose sole object seems to be to afford amusement for the hour; but this feature does not by any means render it the less interesting and attractive.

If we take, for example, Chapters III. and IV., we find that the beginner is taught by means of practical illustrations, not alone the character of "vegetable elements and tissues," but of the organs and functions of plants; and if he takes care to seek out the objects recommended for his observation, he cannot fail to become acquainted with the nature and functions of leaves, stems, roots, flowers and seeds, and with the leading phenomena of fertilization. But our readers may be disposed to think that, in order to instil into the mind of the tyro such an amount of general information, the author must have recourse to technical language, and must avail himself of illustrations difficult of access to the student. By no means: in all such matters the author has smoothed the way for the uninitiated, the burthen of whose labours he has to a great extent borne himself, employing the clearest language, explaining every technicality, and, above all (and this is a great merit in the little work), availing himself, not of the old stock subjects for illustration, but of substances well known to the least informed, and readily procurable by every one.

Here, for example, are the teachings of a cell from the pulp of an apple:—

'Cell-Contents.—In most cells, especially when young, a minute, rounded, colourless body may be seen, either in the middle or on one side, called the *nucleus*. This is very distinct in a cell of the pulp of an apple (Pl. 1, Fig. 2*b*): and within this nucleus is often to be seen another smaller body, frequently appearing as a mere dot, called the nucleolus.

'The nucleus is imbedded in a soft substance, which fills up the entire cell (Pl. 1, Fig. 20); this is the protoplasm (*πρῶτος*, first, *πλάσμα*, formative substance). As it is very transparent it is readily overlooked; but it may usually be shown distinctly by adding a little glycerine to the edge of the cover with a glass rod, when it contracts and separates from the cell-walls, as in the lower cell of Fig. 2. The protoplasm in some cells is semi-solid, and of uniform consistence, while in others it is liquid in the centre, the outer portion being somewhat firmer, and immediately in contact with the cell-wall. In the latter case it forms an inner cell to the cell-wall, and is called the *primordial utricle*. The terms "protoplasm" and "primordial utricle" are, however, used by some authors synonymously.

'The protoplasm is the essential portion of the cell, and it forms or secretes the cell-wall upon its outer surface in the process of formation of the cell, considered as a whole. It is also of different chemical composition, from the cell-wall being allied in this respect to animal matter.'

Thus simply, and with the aid of the cell from the pulp of an apple, does the author convey to his uninformed readers the chief facts in regard to one of the most difficult questions in vegetable physiology; and as he has drawn upon the apple for his illustration in this instance, so he employs the commonest, but by no means the least interesting and attractive objects throughout his survey of organic nature.

From the vegetable kingdom we have the leaf of a geranium, the starch granules of cereals, or of the potato; the stalk of garden rhubarb, with its exquisite structures; sections of deal and holly; hairs of London pride; pollen grains of the crocus, primrose, and sunflower; sting of the nettle; petals, sepals, and other parts of the common chickweed; sections of mustard-seed, &c.; and again, the best known ferns, such as Polypodium and Scolopendrum vulgare, the most familiar mosses, lichens, and sea-weeds, a few of the commonest desmids and diatoms.

From the animal kingdom, which is by no means so largely illustrated, we have the blood-corpuscles of man, of the fowl, &c.; hairs of men and of mice; fibres of flax, silk, and feathers; scales of familiar fishes; heads and weapons of offence of *too* familiar insects; cilia from the gills of the oyster; along with examples of the most widely-distributed Rotifera, Infusoria, and Entozoa: all the objects enumerated, with many more (in all 451 figures) being grouped in twelve plates, well coloured after nature, and engraved by a new microscopical artist, Mr. W. Bagg.

As we have already stated, however, the little work is by no means perfect, much as it deserves our commendation. If, instead of devoting by far the greater portion of his volume to the vegetable kingdom, of attempting to explain the more obscure phenomena of magnification, polarization, &c., the author had favoured his readers with a few more original drawings of the minute forms and microscopical features of animal life, some of the most important of which are left quite unrepresented, whilst those selected are by no means the most beautiful; and if he had appended a chapter on crystals and other inorganic objects, his work would have been greatly benefited, and it would not have been open to the objection that it is rather a guide to the microscopical study of organic nature, than what it professes to be, namely, a text-book of the microscope generally.

We leave these hints with the able author in case a second edition is called for, as no doubt it soon will be, and meanwhile we recommend the book as a fresh, useful little work, full of accurate original delineations of well-classified microscopical objects in organic nature, and not as we sometimes find to be the case in such treatises, a mere patchwork composed of the researches of other men, and with (made up by the help of scissors and paste) a heterogeneous jumble of drawings, correct or otherwise, not one tithe of the objects which they represent having been seen by the authors who profess to describe them.

There is, however, one class of persons to whom the little book will appear very imperfect,—namely, to those who desire, not alone to inspect, but to prepare and mount objects for preservation. The chapter on this subject is very meagre; and to readers thus inclined we have no hesitation in recommending the second work of which we give the title. It must be clearly understood, however, that we have not placed them thus with a view to institute a comparison between them, inasmuch as Mr. Davies's book is devoted solely to the mounting of microscopical objects and makes no pretension to scientific knowledge beyond what is immediately necessary for that purpose.

It is an unassuming little brochure, without illustrations and by no means attractive in appearance, but is composed by an author who appears as modest as he is enthusiastic, and contains, besides his own experiences in preparing and mounting objects, the most approved methods of many of our most eminent microscopists, of Dr. Beale, Dr. Golding Bird, Dr. Carpenter, Mr. Rylands, Mr. Hepworth, &c.; and it instructs the student, not only as to the best method of mounting objects, but how to select those which are the best suited for permanent preservation. It wants a table of contents, and would suffer nothing if the head-lines of the pages were a little more explicit, instead of being, as at present, a mere repetition of the title of the work from beginning to end.

We offer no apology to our readers for having occupied so much of their attention with an account of these two little works, for they represent what is becoming one of the most important intellectual pursuits of our middle and upper classes, and is happily supplanting in the lives of the growing youth of our day many frivolous and mischievous practices. Hundreds there are, both young and old, who would like to follow some intellectual employment during their leisure hours, if they but knew which to select and how to proceed; to such, then, we would recommend a good microscope, and its employment under the guidance of the two little works of which we have here endeavoured to give an unprejudiced account.

THE OPHTHALMOSCOPE AND OPHTHALMOSCOPIC PHOTOGRAPHY.*

In the former part of this number of the 'Journal of Science,' we have given a sketch of the history and uses of the Ophthalmoscope, the practical application of which the two publications whose titles are named at the foot are intended to forward. Mr. Hogg enters fully upon the principles upon which the instrument is formed, the best method of using it, and points out the changes in the fundus of the eye which are discovered by it.

From his previous writings on the microscope, and his familiarity with the laws of optics, the author was well qualified to appreciate the importance of the ophthalmoscope; as he was one of the first to direct the attention of the medical profession to the subject, so he has been one of the most diligent students in this country in its application. The first edition of this book in 1858 was a small, unpretending

* 'A Manual of Ophthalmoscopic Surgery: being a Practical Treatise on the Use of the Ophthalmoscope in Diseases of the Eye.' By Jabez Hogg. 3rd edition, re-written and enlarged. 8vo. Churchill & Sons.

'A New Ophthalmoscope for Photographing the Posterior Internal Surface of the Living Eye, with an Outline of the Theory of the Ordinary Opthalmoscope. By A. M. Rosebrugh, M.D.

volume, while this last edition has not only expanded into a goodly octavo volume, but the contents have increased in value, as the subject has advanced in importance. Those who are interested in the matter merely as one of science, cannot do better than consult Mr. Hogg's book, as they will find in it all that they need ; while those professional men who desire to use the instrument and become qualified to estimate its value, will do well carefully to study its contents; for, as it is one of the latest, so it is one of the most complete, publications in the English language on the subject. Its illustrations, woodcuts, and coloured lithographs of the interior of the eye in health and disease cannot fail to be of considerable use to the beginner. These coloured views are not only more numerous, but also better executed than those in the first edition of the work; still we would call the author's attention to the magnificent illustrations recently published by Liebreich in the 'Atlas d'Ophthalmoscopie,' which as works of art have never been exceeded in beauty of execution, as well worthy of rivalry, when another edition of his book is called for. We well know the difficulty and cost attendant upon the illustrations of such a character, but we cannot doubt that artists in England may be found who are equal to the task, and the extra outlay would be well repaid by the greatly-increased value of pictures which shall equal in delicacy and beauty the original structures which they represent.

The pamphlet by Dr. Rosebrugh is a reprint, from a Canadian Journal, of a paper read by him in January last before the Canadian Institute, in which he describes a new ophthalmoscope he has lately invented for obtaining a photograph "of the posterior internal surface of the living eye." It would be very difficult to convey a clear idea of the apparatus without diagrams. It, however, essentially consists of a modified ordinary photographing camera, in which the tubes and lenses are so arranged, that near their juncture is placed a polished plate of glass, with parallel surfaces, inclined at such an angle to the tubes that a part of the light entering by the illuminating tube is reflected, at right angles to its original direction, into the dilated pupil of an eye, from which it is again reflected upon the back of the camera, when, instead of the image being received upon an ordinary ground-glass screen of a camera, it falls upon a properly sensitized collodion glass, upon which, by about five seconds' exposure, a negative picture is impressed. This negative is then used in the ordinary way for printing the positive photographs.

Though Dr. Rosebrugh does not yet appear to have succeeded in photographing the human eye, he states that he has obtained an impression of the eye of a cat, while the animal was under the influence of chloroform, which condition, however, he hardly thinks necessary, seeing that its impression can be obtained in so short a space of time.

We welcome with much pleasure this ingenious attempt to still further extend the important applications of light painting, which of late have received so many new extensions; we can hardly conceive of any that can be more valuable than this suggestion, for not only are the structures so minute and so delicate, but so varied and so numerous, that it is most difficult even for the fully initiated to clearly define them, so as to make them clear to a bystander. Hence there is little wonder that a non-professional artist who knows not what he is to see, should be puzzled to make them out, and still more so to depict them. Of this, every writer, Mr. Hogg amongst the number, complains, and all find it most difficult and costly, sometimes almost impossible, to obtain truthful representations of those numerous changes in the eye, which the pathologist is so anxious to secure. Should hereafter photography be capable, as we now incline to hope it may be (it has already been most usefully applied in depicting accurately and cheaply external changes and diseases), at no very distant time, of illustrating the hitherto hidden recesses of the human eye, it will supply a desideratum of no ordinary importance; for an absolutely correct picture of the living eye in health and disease will then be within the easy reach of every student of medicine, and thus one great cause of ignorance will be removed. While, therefore, Dr. Roseburgh cannot as yet lay claim to complete success, he deserves credit for the advance which he has made on the road to it.

ELEMENTARY CHEMISTRY.*

Dr. Apjohn, Professor of Chemistry in the University of Dublin, has recently added another to an already numerous class, the Manuals of Chemistry for beginners. It is said that few preachers close their useful careers without, at some time or other, publishing a sermon or volume of sermons. A like result appears to occur under similar circumstances with another class of men. Most of those who have to deliver at stated intervals a course of elementary scientific lectures, in which, owing to the quickly-changing audience, there is not scope for much extension or variety, feel tempted to commit to print their favourite explanations and demonstrations, and not a few yield to the temptation.

As might be expected, the little books developed under these conditions bear a strong resemblance one to another. Dr. Apjohn's manual is a fair specimen of this class, not among the worst, but, we must in honesty add, not among the best.

We prefer, therefore, to offer a few general remarks upon elementary works in chemistry, using that of Dr. Apjohn by way of illustration, rather than to attempt a detailed criticism of a not very characteristic performance. In one respect, however, Dr. Apjohn has departed from the established usage; we mean, in the limitation of his subject-matter. He leaves the vast topic of organic chemistry untouched, excepting that he gives a brief account of a few of the simplest and most commonly occurring combinations of carbon, such as oxalic acid and

* 'Manual of the Metalloids.' By James Apjohn, M.D., F.R.S., M.R.I.A., Professor of Chemistry in the University of Dublin. (One of Galbraith and Haughton's 'Scientific Manuals.') Longmans.

cyanogen. And here he appears to us to follow exactly the right course. But we do not understand why he has preferred to treat only of the metalloids in a work "intended as a handbook in Chemistry for students in Medicine and Engineering." Any group of elements, no doubt, may furnish ample material for a volume addressed to scientific readers; but what a beginner in chemistry needs is a sketch, however slight, of the whole subject; and it seems better that this should be presented to him in a continuous form than in a manual of the metalloids, and, if such a work is to follow, a manual of the metals.

A difficulty attendant upon the first steps taken in any science, is that of remembering or feeling an interest in the facts before acquiring some notion of the general principles under which they have been arranged, and on the other hand, of understanding the general principles without a knowledge of the facts. In chemistry, at any rate, there need be no hesitation as to the alternative a beginner ought to adopt. Dr. Apjohn has followed the usual practice in prefacing his detailed account of particular substances with an introduction, in which he deals with the laws of chemical combination, atomic weights, the classification of the elements, &c. We venture to think this practice inexpedient. Every teacher of chemistry must have had occasion to observe the bewilderment of a beginner, who attempts to read a manual in which this order has been followed. A curious compromise is adopted in the useful volume on chemistry, written by the late Professor Wilson for Chambers's Educational Course. The first fifteen pages are occupied by an excellent account of the method of chemistry, and its relation to other sciences. Then follow fifty pages of theoretical explanations, also good, but to a beginner probably unintelligible. In the preface, the reader is advised to skip these fifty pages, and pass on to the account of oxygen and hydrogen. The plan of first communicating some of the facts of chemistry, and then attempting their explanation, was adopted by Fownes, and is followed also by Dr. Bernays, in his 'First Lines in Chemistry.' We cannot express too strongly our conviction, that in teaching natural science, the historical method should be followed as far as possible. The order of discovery, and of the development of scientific ideas, is obviously not fortuitous, but depends upon a natural connection between one substance, or one mode of thought, and another; and it is in this order that each learner will best advance from facts and ideas which he has already gained to others which to him are new.

One difficult problem which the authors of scientific compendiums have to solve, is that of taking a comprehensive view of a large subject, and using the detail necessary for clearness, within the limits of a manual. They ought therefore to be jealous of admitting to their pages any matter, however useful, which will not directly serve the purpose of conveying to beginners a knowledge of the science. Too often the science lies buried beneath a mass of useful information. The process of purging itself of its applications is, we suppose, one that every science must go through at a certain stage of its development. Each kind of knowledge, before it has become extensive, and before it has imposing generalizations to show, is valued for its uses and not yet for its own sake. At a later stage, when the science is an object of interest independently of its applications, some account of these is not unnaturally mixed up with its teaching, being introduced partly for the sake of illustration, partly to exhibit its practical importance. For example, the books of arithmetic now in common use, and, we believe, still more those of an earlier date, give "rules" for the performance of various commercial calculations, which it is no doubt well to teach to those who will have occasion to use them, but which should be dissevered from the systematic study of the science of number.

We observe to a much greater degree a similar medley of science and its applications in works on Chemistry. We will borrow from Dr. Apjohn's manual a few examples of the kind of useful information which appears to us out of place in a scientific treatise. Under the head "Phosphorus" (p. 389), we find an account of the manufacture of lucifer matches; under carbonic acid, a discussion on ventilation, and an account of the preparation of aërated drinks (pp. 491–493). No less than three-and-twenty pages are devoted to the manufacture, purification, and illuminating power of coal-gas. The following extract from the chapter on Carbon will serve well to convey our meaning:—

"The diamond is valuable for cutting glass, and its powder is much used for cutting and polishing the diamond itself, and the harder gems. It is, however, principally employed as an ornament for the person; and is worked by the lapidary into forms which have received respectively the names of the *rose* and *brilliant*. The *rose* is flat below, and is cut above so as to exhibit 24 facets. The form of the *brilliant* is the same; but it is domed below as well as above, and is similarly cut on the two surfaces. When cut and polished, a diamond weighing one carat is valued at 8*l*., and its price augments as the square of its weight, until this latter reaches 20 carats; above this weight its price rises in a much quicker ratio."

It may be useful to know these facts, but assuredly they have very little to do with chemistry. Descriptions of the mode of preparing substances on a large scale, and tables for ascertaining the strength of an acid from its specific gravity, might also be excluded; the former, because they illustrate no chemical principle which an experiment on the small scale does not better illustrate; the latter, because though invaluable in a work of reference for laboratory use, they are not adapted to be read through or remembered.

The language of chemistry presents grave difficulties to those who are commencing the study, not only because of its lengthy and often barbarous character, but because of its ambiguity, one substance having frequently a number of names. This want of uniformity appears to be a necessary consequence of the rapid progress of the science. New ideas require new words, and until they have met with general acceptance or rejection, the new and the old words are in use together. All that a writer can attempt is to make as consistent a selection as possible, balancing the claims, often opposed, of scientific accuracy and of usage. Even if usage could be summarily disregarded, which is least of all possible in a text-book, a selection on scientific grounds is no easy matter. There are, for example, advantages in a name which involves no hypothesis, such as caustic potash, prussic acid, aniline; and there are advantages in a name which suggests to a chemist the generally received formula of the substance, such as hydrate of potassium, hydrocyanic acid, phenylamine. As chemical knowledge advances, bodies of more and more complex constitution, that is, containing in one molecule a greater number of atoms and susceptible of a greater variety of decompositions, are separated out from natural products and investigated, or are built up by the now systematic processes of chemical synthesis. These bodies we represent by formulæ, which indicate the number and kind of atoms composing their molecules, and suggest as far as possible their modes of formation and decomposition. Chemists have striven to make the language of chemistry keep pace with this increase in their knowledge and in the complexity of their formulæ. Probably the attempt must be given up. It is impossible to compress into a name facts which a formula may convey, but which require sentences for their verbal expression. As a consequence of this attempt, chemical names have become sentences, and it is often shorter as well as clearer to write down the formula of a substance than to call it by its name. In the future nomenclature of chemistry we conceive that the formula of a substance will be its name, and that we shall no more expect to have a word corresponding to every formula than to have a name for every algebraic expression. These considerations, however, apply chiefly to organic chemistry. Where the formulæ of substances are simple, the interval is greater, so to say, between one substance and another, and it has not been difficult to apply to each a characteristic name composed of a moderate number of syllables. Almost the only innovation sanctioned by Dr. Apjohn is the use of the names carbonate of sodium, &c., instead of carbonate of soda, &c. It is to be hoped that this change by which the names of salts become uniform and free from theory may soon meet with general adoption. The old terms 'oil of vitriol,' 'muriatic acid,' 'barytes,' 'strontites,' 'barytic water,' 'water of ammonia,' and others, to which Dr. Apjohn adheres, appear to us to have been deservedly superseded. Dr. Apjohn must pardon us for venturing one or two verbal criticisms. The name metaphosphoric acid does not mean 'phosphoric acid associated with something else (water),' p. 396, but changed, or—to illustrate this use of the preposition—metamorphosed, phosphoric acid. 'Hexangular' is a bad substitute for hexagonal, and such expressions as 'per saltum' and 'quam proximè' have no advantage over their English equivalents.

Graver objections attach in our opinion to expressions of another class still much in vogue among chemists. We mean the phrases, for they are nothing more, which represent as the cause of a phenomenon some hypothetical force or law, whose existence is merely an inference—and, as we think, an unmeaning, unscientific inference—from the phenomenon itself. We still recognize under different guises the famous explanation of Molière's physician. "Why," it was asked, "does opium send a man to sleep?" "Because," answered the sage, "it possesses a soporific virtue." In confirmation of this remark we will make a few extracts from Dr. Apjohn's pages. When describing the process of filling a balloon with dry hydrogen, he says, "The oil of vitriol and potash, in consequence of their great affinity for moisture, dry the gas in its passage to the balloon, and at the same time slightly augment its levity." (p. 135.) That oil of vitriol and potash absorb moisture when exposed to the air, and that heat is developed when they are mixed with water, are facts. We pass beyond our knowledge when we infer from these facts the existence of a cause, resident in these bodies, which we call their *affinity* for water. And when we proceed to speak of this supposed force as accounting for the absorption of moisture or the development of heat, we are simply deluding ourselves with words.

The same remarks will apply, *mutatis mutandis*, to other similar passages. "Sulphur and iron filings, when mixed and moistened with water, have a strong affinity for oxygen. If, therefore, such a mixture be placed in a light capsule floating on water, and that a bell-shaped or cylindric jar be inverted over it, the oxygen of the air is gradually absorbed, and the residual gas is nitrogen." (p. 170.)

And again, with reference to the supposed isolation of fluorine by the action of chlorine gas on fluoride of silver, Dr. Apjohn says:—

"Such an experiment could not be made with any prospect of success in glass or even in a platinum vessel; for though the fluorine was set free, such is the energy of its affinities that it would at once enter into combination by acting on the materials of which the apparatus was composed." (p. 378.)

If we may put confidence in Kämmerer's results, "the energy of its affinities" does not produce this effect. A single line will furnish us with one more example: "Phosphorus is a very inflammable substance, the result of its strong affinity for oxygen." (p. 388.)

We will quote, lastly, from Dr. Apjohn's introduction, his general account of the theory of chemical affinity. It is a clear statement of the common doctrine on the subject.

"We come now to the consideration of affinity, the force in virtue of which two or more simple atoms combine so as to form a compound atom. It is to the chemist the most important of the forces active in nature; for to it he refers the numberless combinations and decompositions of which bodies are susceptible."

Now, there is no point, in our opinion, which it is more important to set plainly before a student, than the fact that, as to the cause of chemical change—the forces, if there be forces, which move the atoms, if there be atoms—we know nothing at all. Science has to do with motion, with changes, with relations, but not with force. Probably, if the term "affinity" could be got rid of altogether, it would be a gain to chemistry; but at least it should be used only, as "vital force" is still sometimes used, under protest, as a name for the unknown cause or causes of chemical action.

But it is not only in the philosophy of chemistry that this negligence in distinguishing between fact and hypothesis is observable. In giving a systematic account of the combinations of the elements, it might be thought an important part of the duties of the writer to discriminate clearly between those substances that have been separated and analyzed, those whose existence is rendered probable either by experimental evidence, falling short of demonstration, or by considerations of analogy, and those in favour of whose existence there is no presumption whatever. The reader of most elementary works on chemistry will look in vain for this distinction. He is presented with the names and formulæ of a host of imaginary substances, many of which are so entirely without analogues that no chemist would dream of attempting their preparation. Dr. Apjohn gives three lists, and similar lists may be found in most chemical text-books, of the oxides of Sulphur, Phosphorus, and Carbon. The first list consists of seven oxides, the second of four, the third of six. Chemists are actually acquainted with two oxides of Sulphur, two, or perhaps three, oxides of Phosphorus, and two oxides of Carbon. Of the remaining oxides it is said that they "exist only in combination." This is one of those treacherous phrases of which chemistry were well rid. In this sense all bodies exist whose formulæ can be made by combining the symbols which compose the formula of an actually existing body. For example, the well-known salt hyposulphite of sodium has the constitution expressed, on the old notation, by the formula $Na\,S^2O^3$. Hence, on this principle, we may infer the existence of substances having the following formulæ:—$Na\,S$, $Na\,S^2$, $Na\,O$, $Na\,O^2$, $\mathit{Na\,O^3}$, SO, SO_2, SO^3, $\mathit{S^2O}$, $\mathit{S^2O^2}$, $\mathit{S^2O^3}$, $\mathit{Na\,SO}$, $\mathit{Na\,SO_2}$, $Na\,SO_3$, $\mathit{Na\,S^2O}$, $\mathit{Na\,S^2O^2}$; of these substances those whose formulæ are printed in italics "exist only in combination." The reason why the formula of one of these imaginary bodies figures as that of "a known oxide of sulphur" (p. 256), is the traditional acceptance of the dualistic hypothesis, according to which every salt containing oxygen consists of a metallic oxide and an acid anhydride. Now we are far from saying that this oxide of sulphur may not hereafter be made, or that there is no argument from analogy in support of this anticipation. Only the same may be said of nearly every one of the hypothetical bodies whose formulæ we have written down. The discovery of the teroxide of sodium, of the protoxide and suboxide of sulphur, of the sodium salts intermediate between the sulphide and sulphite, appears at least as probable. These indications of what we may hope to realize, drawn from the analogy of existing compounds, are the clue which must guide the chemical investigator; but to set before a beginner the names and formulæ of certain substances selected on a particular hypothesis,—one out of many that have been formed,—from among hundreds of others, equally possible, equally unknown, is a course in the highest degree arbitrary and misleading.

We wish to repeat, in conclusion, that our object has been to call attention to various points in which, as we venture to think, the traditional teaching of chemistry is in fault. We have thus been led to notice chiefly those parts of Dr. Apjohn's manual which illustrate the objections we have advanced, and have left without comment, as beside our purpose, the large amount of well-arranged information which it contains. But while we readily share the modest hope which Dr. Apjohn expresses, that his manual will materially assist his chemical pupils in the University of Dublin, we must express our opinion that a text-book of chemistry, such as we would desire to see in the hands of every beginner, has yet to be written.

BOTANIST'S GUIDES.*

Dr. Dickie having been for some years resident in Belfast as Professor of Botany and Natural History in Queen's College, has examined the Flora of the northern part of Ireland, and the result is given in the first-named publication now before us.

Like all the works of the same author, it displays accurate observation combined with a thorough knowledge of species. The district embraced in the 'Flora' lies to the north of the fifty-fourth parallel of latitude, and extends due west from Dundalk. It includes the whole of Ulster (except the most southern portions of Monaghan and Cavan), and the northern portions of Leitrim, Sligo, and Mayo, belonging to Connaught. As to the general geological features of the district, it is stated that Silurian formations occur in the South-east, Metamorphic and Granitic rocks in the North and North-west, Carboniferous Limestone in the South-west, and Devonian rocks in part of the interior. In the East there is an extensive mass of basalt and chalk; greensand and oolite are here and there exposed. The extreme highest points are;—in county Down, Sleeve Donard, 2,796 feet; in Donegal, Muckish and Engal, respectively, 2,190 and 2,400 feet; in Mayo, Nephin, 2,646 feet. Surrounded as Ireland is by the Atlantic, and its northern parts so indented that arms of the ocean extend considerably inland, as might be inferred, the climate of even the most northern parts is comparatively mild and moist. The extreme ranges of temperature are moderate when contrasted with those recorded in different parts of Great Britain. The character of the 'Flora' indicates this. In marine plants the occurrence of many southern species in the sea of the North of Ireland points out the influence of the Gulf Stream in a marked manner.

Taking Mr. W. C. Watson's divisions, Dr. Dickie gives the following statements as to the Ulster Flora:—

1. British.—The number of plants belonging to this division, as given in the Guide, are—Dicotyledons, 347; Monocotyledons, 136. Several of these are not so abundant as usual, such as *Draba verna, Cardamine amara, Arabis hirsuta, Adoxa Moschatellina, Origanum vulgare, Myosotis collina, Mercurialis perennis, Milium effusum, Carex fulva.*

2. English.—The total number of this type in the British Flora is about 396; of these there are, in this district, 141 Dicotyledons and 36 Monocotyledons, giving a total of 177.

* 'A Flora of Ulster, and Botanist's Guide to the North of Ireland.' By G. Dickie, A.M., M.D., F.L.S., Professor of Botany in the University of Aberdeen. Belfast: C. Aitchison; London: Lovell Reeve. 18mo, pp. 176.

3. Scottish.—The total number in Britain may be estimated at about 69; those in the Ulster list are 34 Dicotyledons and 19 Monocotyledons; total 44.

4. Highland.—Species of this type are estimated at 100; in the North of Ireland the number is 29, of which 26 are Dicotyledons.

5. Atlantic.—The total number in Britain is about 60; of these there are in the list 23, of which 20 are Dicotyledons.

6. Germanic.—The representatives of this type are 190, and only 3 are in the list, of which 2 are Monocotyledons.

7. Local.—Under this head are included 2 species not found in Britain—*Arenaria ciliata* and *Carex canescens*, and one, *Calamagrostis stricta*, extremely local in Britain.

The plants which occur on the summits of the higher mountains are as follows:—*Arbutus Uva-Ursi*, *Calluna*, *Empetrum*, *Galium saxatile*, *Salix herbacea*, *Vaccinium Myrtillus*, *Carex pilulifera*, *C. rigida*, *Festuca ovina*, and *var. vivipara*, *Luzula sylvatica*, *Juncus squarrosus*, *Poa pratensis*, *Armeria vulgaris*, *Campanula rotundifolia*, *Euphrasia officinalis*, *Potentilla Tormentilla*, *Rumex acetosa*, *Agrostis vulgaris*, *Aira flexuosa*, *Lycopodium Selago*, *Saxifraga umbrosa*.

The author includes in the 'Flora' the Phanerogamous plants along with Ferns and their allies. A list of the species is given, with full reference to their localities, a notice of their period of flowering, their range, and the type to which they belong. A supplement is given containing a list of the species which are either not strictly indigenous, or regarding whose occurrence in the district there is some doubt. We have no hesitation in recommending the work as one of great value to the botanist who wishes to explore the Flora of the North of Ireland.

The counties embraced in Dr. Dickie's 'Botanist's Guide'* to Aberdeen, &c., are very interesting in a botanical point of view. They exhibit a Flora ranging from the sea-shore to the height of 4,295 feet. The author gives a general view of the physical character of the counties, and notices specially their meteorology. The geology of the counties is also given, from the pen of Mr. Cruickshank. The British Dicotyledenous orders not represented in the Flora are Berberidaceæ, Frankeniaceæ, Tiliaceæ, Aceraceæ, Balsaminaceæ, Celastraceæ, Rhamnaceæ, Tamariscaceæ, Cucurbitaceæ, Loranthaceæ, Jasminaceæ, Orobanchaceæ, Amarantaceæ, Elæagnaceæ, Thymelæaceaæ, Santalaceæ, and Asaraceæ. The Monocotyledonous orders not represented are Amaryllidaceæ, Tamaceæ, Hydrocharidaceæ, and Restiaceæ.

Taking Mr. H. C. Watson's Floral types, the following report by the author gives an idea of the characteristic features of the Aberdeenshire Flora:—

1. British.—Most of these constitute our common plants, almost everywhere diffused, and many of them familiar to all as ordinary weeds. Some of this type, however, though abundant in more southern

* 'Botanist's Guide to the Counties of Aberdeen, Banff, and Kincardine.' By G. Dickie, A.M., M.D., Professor of Botany in the University of Aberdeen. 18mo, pp. 314. Aberdeen: A. Brown & Co.; London: Longman & Co. 1860.

parts of Britain, become scarce here, and may be reckoned among our rare species; such as Ranunculus auricomus, Arabis hirsuta, Arenaria trinervis, Bidens cernua, Lycopus Europæus, Listera ovata, Malaxis paludosa, Alisma ranunculoides, &c.

2. English.—Of this type comparatively few reach Aberdeenshire, and some of them, though now extensively spread, very probably may have been introduced along with seeds of agricultural plants.

3. Scottish.—Plants of this division are well represented in this part of Scotland, being 58 in number, and, therefore, about $\frac{5}{6}$ of the British species, so designated, occur here. Most of them are abundant, and several are species highly prized by Southern collectors. A few examples may be mentioned:—Rubus saxatilis, Trientalis Europæa, Linnæa borealis, Pyrola media, Pyrola minor, Goodyera repens, and Listera cordata. Three of these, Linnæa, Trientalis, and Goodyera, may be specially noted as very widely distributed and abundant here.

4. Germanic.—There are only 8 examples of this type on our list, and they are mostly rare or local plants; the total number of such in the British Flora being estimated at more than 190.

5. Atlantic.—Sedum anglicum and Scilla verna are the only representatives; the latter confined to the North-western part of the coast, on the borders of the Moray Firth.

6. Highland.—The plants belonging to this division are estimated at about 100 species in the whole British Flora; of these $\frac{8}{10}$ are found in the list. Many of these are very local, and entirely confined to the higher districts. A few of these reach the coast, and are found almost at the sea-level, *viz.* Sedum Rhodiola, Saxifraga oppositifolia, S. hypnoides, and Polygonum viviparum. Some others appear at a lower altitude along the course of the Dee and Deveron. Such have, probably, been transported by floods, *viz.* Oxyria reniformis, Epilobium alpinum, and Alchemilla alpina. Among the more interesting of this type found in the interior, and usually very local, may be mentioned Astragalus alpinus, Mulgedium alpinum, Arbutus alpina, and various species of Saxifraga, Hieracium, Salix, Juncus, Carex, and Poa.

As regards altitudinal distribution, the following remarks are made:—The upper limit of Pteris aquilina is considered as marking the upper limit of the Super-agrarian Zone, and therefore also that of cultivation in Britain. The limit of this fern varies here from 1,600 to 1,900 feet: very rarely, however, does it attain the latter. In several localities, on the bare stony sides of the hills, the limit is found to be 1,600 to 1,700 feet. At various places, even more than forty miles from the sea, cultivation at high altitudes is frequent. In some of the inland or higher parts of the Super-agrarian Zone, several plants of the Highland type constitute a permanent feature of the vegetation, such as Cerastium alpinum, Asplenium viride, Polygonum viviparum, and Arabis petræa.

The Zones of Watson's Arctic region are well represented in Aberdeenshire. The Mid-Arctic Zone is peculiarly rich in rare forms of the Highland type, such as Astragalus alpinus, Carex rupestris, C. leporina, C. Vahlii, Erigeron alpinus, &c. At the extreme part of the Super-Arctic Zone, the Highland forms alone occur. Thus, on the summit of Ben Macdui, only seven flowering plants are found, *viz.* Silene acaulis, Saxifraga stellaris, Salix herbacea, Luzula spicata, L. arcuata, Carex rigida, and Festuca vivipara. Along with them are associated Lycopodium Selago, and several other Cryptogamic plants.

A complete list is given in the work of all the Phanerogamic and Cryptogamic plants of the counties, and full references to their localities. There is also a map of the district, with a delineation of the various zones of vegetation, and a notice of the plants which mark different altitudes. The 'Guide' is compiled with great care and correctness by one who is thoroughly conversant with the Flora, and who has for many years been in the habit of visiting the localities. Dr. Dickie has done good service to practical botany by this publication, which ought to be the pocket companion of every one who means to explore the floral treasures of the North of Scotland.

BRITISH AND AMERICAN CONCHOLOGY.*

Whatever may be the future destiny of those constituent groups which collectively form the genera of natural science, it is certain, that from the time of Linnæus they have, in numberless instances, endured a considerable amount of severe cross-examination, and have stood their ground with much firmness. Species are indeed, at present, somewhat stubborn facts, and exhibit not a few very remarkable idiosyncrasies, which have to be disposed of before the theory of development can be regarded as perfectly established.

To an unprofessional observer, the aspect of a named collection, in almost any branch of natural history, is very perplexing. In entomology, for instance, he may notice a series of insects, under the same specific name, yet differing from each other in size, colour, and even in form; whilst not far from these, two groups may appear, in one of which the specimens are so like those of the other, as to be apparently indistinguishable, yet he may find the groups marked by different specific, perhaps even by different generic, names. The arrangement may, nevertheless, be perfectly accurate and easily intelligible to the entomologist, who, in a variable species, at once recognizes the specific identity of insects, differing at first sight, as much as a magpie does from a jay; whilst between two constant species, he knows the characteristic difference is very slight. We may be more or less inclined to attach importance to specific dis-

* 'British Conchology; or, an Account of the Mollusca which now inhabit the British Isles and the surrounding Seas.' Vol. II., 'Marine Shells: comprising the Brachiopoda and Conchifera, from the Family of Anomiidæ to that of Mactridæ.' By John Gwyn Jeffreys, F.R.S., F.G.S., &c. Van Voorst.

'Observations on the Genus Unio: together with Descriptions of New Species, their Soft Parts and Embryonic Forms in the Family Unionidæ.' By Isaac Lea, LL.D., President of the Academy of Natural Sciences of Philadelphia, &c. With ten plates. Philadelphia: Printed for the author.

tinctions, but at all events, it must be evident that discrimination between species is a matter of empiricism, and can only be accomplished by a naturalist who has a thorough practical acquaintance with all the constituents of a genus in their various relations towards each other, and under all the circumstances of the life-history of each species.

Dr. Lea has devoted a large share of his life to the attainment of a thorough acquaintance with the single conchological family Unionidæ. The Unios are not general favourites with shell collectors, perhaps because there is, to say the least, a strong family resemblance between all the species, and a good series requires the whole of a very capacious cabinet for its reception. Nevertheless, these fresh-water mussels have had a few enthusiastic admirers and collectors, from and before the time of Featherstone, whose book of travels in North America gives an amusing account of perils and hardships undergone in pursuit of Unios. The tenth volume of Dr. Lea's work on the Unionidæ contains a very valuable description of the soft parts and embryonic forms of many species, the shells alone of which had been previously described. It is a pity that the work is so strictly confined to technicalities. Books of natural science will never gain their due respect from mankind till they openly recognize the fact that an accurate description of the habits and dispositions—in short, the biography of a living thing—is just as purely and as truly scientific as the most elaborate treatise on its physiology.

The North American Unionidæ include, according to Dr. Lea, more than seven hundred species, whilst the rivers in Europe do not produce more than a dozen.

The second volume of British Conchology, by Mr. Jeffrey's, exhibits equally with the first, on the part of the author, a profuse expenditure of time and energy ungrudgingly bestowed on his favourite pursuit.

In reading the book, it is easy to fancy oneself inhaling the fresh odour of the sea-shore, or of the sea-bottom; turning a stone for a chiton, or poring over the dripping contents of a dredge in search of rissoæ; on the whole, however, the proportion of matter unattainable from other sources seems to be somewhat less in this than it was in the former volume. Many readers will, no doubt, think that the author has acted judiciously in abstaining from drawing inferences from his vast store of facts, either in favour of, or in opposition to, the theory of natural selection; yet it is daily becoming more difficult to awaken any interest in matters which were the subjects of warm discussion only a few years ago. Even the discovery of a new species is less cared for: we want to know more of the old ones; for if Mr. Darwin's theory be the correct one, there is not an animal or a plant of any species—far more than this, there is not a single character belonging to an animal or a plant of any species, but it has its own wondrous ancestral history to yield as a reward for patient study. On the other hand, if we regard "natural selection" as a mere conjecture, *every part of every living* thing may be examined as a witness to the probability or the improbability of the grounds on which the conjecture has been made. All must admit that Mr. Darwin has fairly challenged refutation; he has propounded no misty, indefinite, unintelligible theory; he has made two assertions that anybody may understand—1st. That species have arisen by divergence in descent from a common stock; 2nd. That the direction of the divergence has been determined on utilitarian principles. It is inconceivable that such a theory can long remain undecided. It is a reproach to science, that the materials for its support or refutation are not at hand in overwhelming plenitude. From a Rhizopod to an elephant, from a particle of red snow to a Wellingtonia, every organism invites the inquirer after truth to come and hear what it has to say upon the question. The fact is, that naturalists have been too much occupied with systems of classification, and with establishing their various personal claims to scientific honours; and now the work that might have been done long ago, remains to be done; for Mr. Darwin himself would be the last man in the world to assert that he had arrived at anything like a demonstration. He has, however, succeeded in giving the great problem a most unexampled prominence; the rising generation will probably possess its satisfactory solution.

PAMPHLETS.

The Colossal Bird of Madagascar.*

In the year 1850, a French ship-captain, named Abadie, being on the south-east coast of Madagascar, observed in the hands of a native the shell of a gigantic egg, which had been perforated at one of its extremities and employed for domestic purposes. M. Abadie being attracted by the unusual dimensions of the egg, set to work to procure specimens of it, and ultimately succeeded in obtaining from the natives, besides the example first seen, two others. One of these was found in the *débris* of a recent land-slip, the other was disinterred from a recent alluvial formation, together with some bones of apparently no less gigantic size.—Upon these objects, which were shortly afterwards forwarded to Paris, the late Professor Isidore Geoffroi St. Hilaire founded a new genus and species of extinct Struthious birds, allied to *Dinornis*, for which he proposed the name, *Æpyornis maximus*.† The most striking character of the eggs of *Æpyornis* is their enormous size. The largest of the two received at Paris measured in circumference lengthwise no less than 2 feet 10 inches, and breadthwise 2 feet 4 inches. Its extreme length in a straight line was about 12 inches. Professor Geoffroi St. Hilaire estimated that it would contain $10\frac{1}{8}$ quarts, or nearly as much as six ostrich-eggs. A large ostrich egg, we may mention, measures only about $6\frac{1}{4}$ inches in length, being little more than half that of the *Æpyornis*. But it would be very hazardous,

* 'A Paper upon the Egg of Æpyornis Maximus, the Colossal Bird of Madagascar.' By George Dawson Rowley, M.A.

† Compt. Rend. de l'Ac. Sc., 1851, Jan. 27.

as Professor Owen has remarked, when making observations on these eggs before the Zoological Society,* to conclude hence that the size of the bird was in proportion to the great dimensions of its eggs. The little *Apteryx*, or kiwi of New Zealand, produces an egg $4\frac{3}{4}$ inches in length, and, when freshly laid, "nearly equal to one-fourth of the weight of the living bird."† In fact, Professor Owen considers that the "*Æpyornis* did not surpass in height or size the *Dinornis giganteus*, and that it was probably a somewhat smaller bird."

The eggs of the *Æpyornis* are now well known to scientific men, from casts which have been prepared to imitate the originals in the French collection, and liberally distributed amongst all the principal Museums of Europe and America. But, as regards originals, the Parisian examples have remained, as far as we know, unique, until the arrival of the example described in the present pamphlet, which was first exhibited in the International Exhibition of 1862. It was obtained, Mr. Rowley informs us, at Mananzari, on the east coast of Madagascar, at a depth of 5 feet in a hill of ferruginous clay, by some Malgaches digging for iron ore. Mr. Rowley tells us that this specimen, which he obtained by purchase from a M. Brunet—the secretary of a French charitable association — slightly exceeds the two Parisian eggs in dimensions, and is, therefore, the largest known example of the eggs of *Æpyornis*. Without grudging Mr. Rowley the acquisition of such an addition to his collection of eggs, for which, we believe, he paid a handsome price, we cannot help expressing our regret that the authorities of the British Museum, to whom we know the offer was made, did not secure such a prize for our national collection.

Spectrum Analysis.‡

We may commend this little book to our readers as an excellent practical guide to the use of the Spectroscope, which all who are beginning to experiment with the instrument will do well to study. Whether its revelations, so far as the materials of our own globe are concerned, are come to an end or not, it will always be looked upon as an important means of research, with the use of which every chemist will do well to make himself acquainted. Although the application to qualitative analysis seems limited and somewhat delusive, there are some who anticipate the day when further researches may show that the spectroscope will be available not only to discover the presence of different substances, but also to show their several proportions. In these hopes we hardly share, but we are glad to lend any aid to extend the use of the instrument.

One objection often brought against the usefulness of the spectro-

* *See* P. Z. S., 1852, p. 9.

† *See* Sclater, in P. Z. S., 1859, p. 350.

‡ 'Instruction Pratique sur l'Analyse Spectrale, comprenant: 1. La Description des Appareils; 2. Leur Application aux Recherches Chimiques: 3. Leur Application aux Observations Physiques; 4. La Projection des Spectres.' Par M. Louis Grandeau. Paris: Mallet-Bachelier.

scope is its excessive delicacy. It is hard, sometimes, to tell whether the spectrum seen is given by the material under examination, or whether it is not caused by minute portions of the substances floating in the atmosphere. It is for this reason that M. Grandeau insists strongly upon the necessity for a separate and distinct laboratory in which to carry on spectrum investigations. This laboratory, he adds, should be provided with the means of effecting a thorough ventilation, so as to get completely rid of volatilized matter.

The author also points out the advantage of securing a room with a southern aspect, the window of which can be darkened with wooden shutters, a circular hole in one of which may admit a beam of solar light for examination and comparison.

No less useful to chemists beyond the reach of gas, is the hint that in the absence of a Bunsen's jet the best source of heat and light to employ is a lamp fed with wood spirit. It is also very properly pointed out that when either such a lamp or a common spirit lamp is employed, the brass collar through which the wick passes should be well platinized to prevent the appearance of the spectrum of copper, some of which metal is always carried along by the spirit.

The spectrum of copper is rather complicated, but it may mislead a young experimenter, who would, however, be able to set himself right, if he checked his results with the spectroscope by an ordinary chemical analysis. And here we may mention what M. Grandeau calls a most happy coincidence. It is the circumstance that those substances which are most difficult to detect by purely chemical means, are just those which give the most simple and characteristic spectra. Take as an illustration the fact mentioned in our Chemical Chronicle. Plattner had a large amount of cæsium in his hands, and yet failed by chemical means to discover that it was anything different from potassium. Bunsen had a very minute proportion, but instantly recognized in the two blue lines the sign of something new. How minute a proportion of some metals may be discovered is stated by the author, and we quote his statement without, however, guaranteeing the accuracy of the determination. He says, that the observation of the lines of the spectrum enables us to prove most distinctly the presence of 0·000,000,3 of a milligramme of sodium, and 0·000,000,9 of a milligramme of lithium!

The exact value of the spectroscope in analysis is, as we have hinted, yet to be determined, but the value of the results already arrived at by its means are unquestioned. Four new simple bodies have been brought to our knowledge in the same number of years, a result unprecedented since the time of Davy; and although a chemist can hardly wish the mumber of simple bodies to go on extending at this rate, we hope there is yet a rich harvest to be reaped to reward the labours of other observers.

We have already expressed a warm commendation of this book, which we have only to add extends to every part but the chromolithographs at the end. If anyone should arrange for its translation into English, he had better get fresh plates executed.

NOTES AND CORRESPONDENCE.

Recent Contributions to Natural History and Ethnology in France.—1. Pasteur on Ferments; 2. Tremaux on the White and Black Races in Africa; 3. Lartet and Christy on Pre-historic Human Remains. By Th. Lacaze Duthiers (Professeur à l'Ecole normale sup. de Paris).

At the time when Lamarck wrote, it was still possible to believe in spontaneous generation; and, indeed, it was easy to justify such a theory by a reference to facts then unexplained, and otherwise inexplicable. But since then, further light has been thrown upon a whole series of living forms, whose origin and development had before been regarded as insoluble problems. The advocates of the theory of generation without parents, or "heterogenesis," as it is termed, rapidly decreased in number, owing to the difficulty they found in sustaining their opinions, and a period seemed to have arrived when such inquiries had attained a degree of precision which excluded the possibility of a revival of this old world controversy.

Nevertheless, M. Pouchet, of Rouen, doubtless unconvinced by the most recent discoveries which had thrown such light upon the mystery of generation amongst the lower animals, some years since presented to the Academy of Sciences a number of detailed facts which, he believed, demonstrated satisfactorily the production of microscopic organisms without parents. This communication led to a controversy, and the Academy of Sciences adopted the question as the subject for one of its prizes, and finally awarded the distinction to an eminent chemist, M. Pasteur, whose labours clearly exhibited the errors into which M. Pouchet had fallen. Still the naturalist of Rouen does not acknowledge himself vanquished. Far from this, he is incessantly attacking M. Pasteur; with him have allied themselves MM. Jolly and Musset, naturalists holding similar views, and the combination of these three observers necessarily gives weight to the opposition raised against the decision of the committee which had already judged the whole question.

In the interests of science, and for the dignity of the Academy of which he is now a member, M. Pasteur has requested that a commission should be appointed with a view of witnessing a series of comparative experiments to be instituted by his adversaries and himself, and the decision of the judges should finally dispose of the controversy. The challenge was frankly and distinctly given; it was accepted in the same spirit by his opponents; and each party was to repeat its experiments before the committee in confirmation of its views.

The time arrived, when MM. Pouchet, Jolly, and Musset requested an adjournment, fearing that the changes of temperature in the spring might cause the failure of their so-called physiological experiments. The delay has been granted, and the commission will not meet until the 19th of June of the present year. As we may well imagine, M. Pasteur has not failed to draw attention to the fact that he was ready at any time, and at the call of the Academy, for with a stove any requisite temperature may at all times be obtained for any kind of experiments.

We trust that there may be no further delay, for it is necessary indeed that a solution, free from any kind of suspicion, should be arrived at, in order to close a debate already too long protracted.

The experiments of M. Pasteur are possessed of singular clearness, precision, and interest, and are conducted on the broadest general basis. He is not content to take at hazard a few special results; but he studies the more extended phenomena of putrefaction, fermentation, and disorganization of organized beings. Wherever he observes the decomposition of an organic compound he also encounters myriads of forms, be they animal or vegetable, which accomplish this decomposition. He seeks the conditions necessary for their existence, in order to deduce from these the laws of their development and reproduction, and in the major portion of the phenomena attributed to slow oxidation, such as fermentation and putrefaction, he sees only the manifestations of the vital force exerting itself in the world of infinitely minute beings.

"*Life*," he says, "*presides everywhere over the work of death*," a remarkable expression, which exhibits strikingly the practical and philosophical mind of the great academician. As a naturalist I heartily approve this statement, emanating from a chemist, for it is, to me, an indication of a return to the study of true biological science—a science far too much neglected, and one, the importance of which is often misapprehended, and its action too much restricted.

When, owing to the new line of inquiry here indicated, the results due to vital force, or, if the phrase be preferred, due to the action of the organized world upon itself, are fully recognized; results of the most striking character which are often attributed to the *chemical* or *physical* forces in the explanations of the phenomena of daily life, then it will be seen that the return of the primitive elements to the inorganic world is but the manifestation, the most striking, though apparently the humblest, of the endowments of animal and plant life. It would be impossible to refer here to all the varied observations of M. Pasteur on this subject; all we can do is to direct attention to his latest communications, which are of a specially practical character, and it is pleasing to see science descend from the lofty heights of theory in order to guide the researches of the experimentalist, so often conducted in the dark.

Everyone is aware that the "must," or sweet juice of the grape, is converted into wine by the process of fermentation, but this being accomplished, whence does wine obtain its exquisite properties? how does it acquire age?

That the oxygen of the atmosphere was indispensable for fermentation was proved by Gay-Lussac; but M. Pasteur teaches us that, when the fermentation is ended, its part in the process becomes changed. It is absorbed, and, combining with some of the elements of the wine, modifies its flavour and imparts to it its characteristic bouquet.

This explains why wine acquires age more quickly and more readily in porous wooden vessels, where the conditions of absorption are favourable, than in glass vessels; in casks rather than in bottles; in a state of motion rather than when at rest. More attention should therefore be devoted than is usually the case to the aeration, not only of cellars, but also of wine contained in casks.

The must is changed into wine by the action of a lowly-organized plant* which, while developing and multiplying itself infinitely, acts upon the sugar and separates its elements.

When the alcohol resulting from this process is produced, absorption

* Mycoderma Vini.

of oxygen commences; the wine loses some of its qualities and acquires new ones. In a word, it acquires age. But this absorption may be hindered or interrupted by the production of many kinds of vegetables; true parasitic growths, which act like ferments, and so form, by their own peculiar influence, those wines which are commonly named in France sour or acid wines, sweet, bitter, turned, and dry wines.

M. Pasteur, without any hasty attempt at imposing new names on each of these vegetable forms (and in this respect how few botanists would have imitated him), regards them, nevertheless, as so many distinct species, which, by their special action, cause the disagreeable characters of which we have just spoken; and he adopts this practical application well worthy of attention.

The disagreeable flavour of acid wines, of those which are sweet, bitter, changed, &c., cannot be recognized by taste until the change is far advanced, and it is no longer possible to apply a remedy to the mischief; while by microscopic examination the destructive cryptogam may be discovered as soon as it is fairly developed, and its increase may then be checked. A wine may thus be out of condition for a long time before its state is really suspected, and microscopic examination alone can ensure the detection of this state, or watch over its progress.

Doubtless it will be long before full use is made of these scientific data, as well as of the microscope; but we shall not be the less indebted to M. Pasteur for having entertained the happy idea of applying his researches, first undertaken from high and purely theoretical views, to the benefit of a branch of industry so widespread as that of the manufacture and preservation of wines.

Although the variability in a species is considered by some naturalists to be unlimited in extent, yet in the case of man the races to which it has given rise are, some of them at least, so characterized and fixed as to have been regarded by certain ethnologists as distinct species. Now, however, the impression exists, and in this there is very general agreement, that only one single species should be admitted for the human race. But this very intricate and difficult question still remains to be solved: Do the different human races spring from one and the same stock very widely modified, or were they distinct at their origination?

The perplexity we experience in giving a satisfactory answer to this query must cause us to welcome with the most lively interest all observations which are able to throw any light upon it; and in this view we shall here refer to the researches that M. Tremaux has just laid before the Academy of Sciences, for the purpose of showing that in spite of the most distinctive characteristics which appear to divide these races, they may still merge one into another. M. Tremaux was induced, by a concurrence of private events, to undertake a long expedition towards the source of the Nile, and whilst there he was led to make some observations, the results of which, if they are confirmed by subsequent inquiry, will become of very material value. He has remarked that the physical characteristics of the white races are changed into those of the black to the south of the mountains of Upper Egypt, and that on the other hand the black races become white towards the north. In delineating upon a map the position of the peoples of the Soudan, he has drawn tortuous lines, representing promontories, gulfs, and islands, as the limits of the various tribes, and corresponding to the variations in the tribes; and he has found that this map, originally intended only to give an idea of the ethnography, has proved in reality to be the geological map of these countries.

This result, very curious in itself, led him on very naturally to inquire whether some relation might not exist between the nature of the soil and the physical forms of the inhabitants. M. Tremaux has not failed to prosecute this line of research, and by comparing the facts gleaned from science concerning the geology of different points of the globe, with the well-known characters of the people there resident, he has been led to the conclusion that remarkable coincidences exist between the geological formations and the human types. The man who differs most widely from our present white type, lives on the soils of oldest formation, whilst he whom we may regard as the most perfect, belongs to those countries which in the smallest space exhibit the greatest variety of soils, and appertaining to the most modern deposits. The observations of M. Tremaux cannot easily be verified; for long, costly, painful, and even dangerous journeys would be imperative; but the attention of those travellers, who are also naturalists, may well be directed to the opinions which he advances. For they have this especial peculiarity (one rarely to be met with in science) that they are not the result of preconceived ideas, and that the author has only been induced to give them to the world, because, so to speak, he was compelled to yield to the evidence of facts which presented themselves before him whilst engaged in a totally different pursuit.

His conclusions tend to show what influence the dwelling upon certain soils, or in certain localities, would have upon the physical characteristics of man; an influence, which, if fully demonstrated, would explain how the white man has become so modified as to produce the type from which he most widely differs, the Negro—namely, by coming to inhabit those countries where the soil has been formed from the earliest deposits; and how the Negro, on his side, has been able to reach the white type, *viz.* by emigrating to countries formed from soils varied in character, and of recent origin. We repeat, it is necessary to confirm these conclusions, and it would be as imprudent to accept them without reserve as it would be to reject them without due investigation. The inquiry is full of interest, not only so far as the philosophy of science is concerned (for it is intimately linked with the question of mutability of species), but also in connection with the progress of the natural history of man, with which we are now so actively employed.

Naturalists will certainly not have forgotten the sensation which was created last year by the presentation to the Academy of Sciences by M. de Quatrefages of a human jawbone found in the quaternary deposit of the Somme by M. Boucher de Perthes. Incredulity, disdain, and irony greeted the new discovery of the learned and now celebrated archæologist of Abbeville, as, indeed, it had been the case with his earlier announcements.

Very shortly afterwards a sort of scientific congress met at Moulin Quignon, to decide whether the famous jawbone found in this locality were really authentic and contemporary with the deposits where traces of human industry had been recognized side by side with huge fossil mammalia. How the conditions are now changed! how far we are removed from that! To-day every one is convinced; and all listen eagerly to any new communication relating to the drift which attests the antiquity of man. Such evidences it is, indeed, easy to find in a country which, like France, is rich in the indications of the very remote existence of an aboriginal race.

The traveller who departing from Paris for the plains of the Garonne, follows the line of the central railway of France, cannot fail to be struck in the neighbourhood of

Périgueux with the appearance of a bed of gravel intermixed with flint, which reminds him of the diluvium of St. Acheul, near Amiens; and after passing further southward, and having reached the valleys of the Beune and of the Vezère, especially towards the station of Eyzies, he must notice, even in the hasty railway journey, the excavations into which the steep rocks, which border on the course of the river, are hollowed out. This part of the centre of France had been until lately very imperfectly explored, but MM. Lartet and Christy, both well known as geologists, have jointly examined the grottos of Périgord. They have collected some objects of extremely high scientific value, which certainly throw a very clear light upon the history of primitive man.* Amongst a mass of flints formed into hatchets, knife-blades, arrow-heads, of bones worked into the shape of needles, of barbed arrows, of harpoons, of amulets or ornaments, and of daggers; and evidencing the existence, among a primitive people as yet ignorant of the use of metals, of a certain kind of industry, and even of art; these gentlemen have been so fortunate as to discover some daggers,† the

Fig. 1.

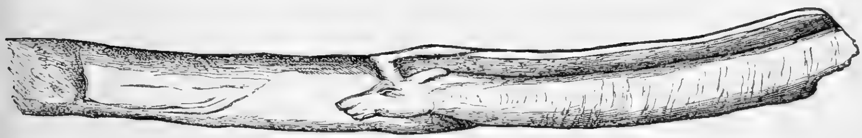


Fig. 2.

handles of which, although roughly carved and sculptured (Figs. 1 and 2), allow us to recognize without the possibility of a doubt that the engraver has wished to represent the reindeer then living before his eyes. Thus not only the material of which the weapon is formed, but also the designs which ornament it, bear witness to the presence of this animal in the middle of France in pre-historic times.

A piece of carving upon an arrow, unfortunately mutilated in its most important part, the head, gives the impression that the Aurochs (bos urus) was also existing in this same country. For the height of the line of the back above the shoulders

* The observations of these gentlemen, at first presented to the Academy of Sciences (part 58) in 1864, have been published in the 'Revue Archéologique,' 1864.

† These drawings are copied from the "Memoir of MM. Lartet and Christy," in the 'Revue Archéologique.'

in this drawing can only refer to that animal (Fig. 3). Lastly, one other relic presented to the Academy of Sciences is a lumbar vertebra of a

FIG 3.

young reindeer, traversed from side to side by a flint with sharpened edge, which is still fixed in the wound it had made in the bone.

Who would, for an instant, refuse to recognize in this the action of the hand of man?

M. Peters has besides discovered in the specimens which MM. Lartet and Christy had forwarded to the museum at Vienna a human incisor.

It results, then, from the whole of these observations that a race of men ignorant of the use of metals lived in Périgord upon the animals procured in the chase and upon fish at a time when the reindeer, the aurochs, and other animals also existed; that they had not tamed any species of animal, not even the dog, and that they made use of the skins of animals sewn together as garments.

This is proved by the discovery of needles made of bone, and of the incisions recognized upon the bone of the leg of the reindeer, from which the people had taken the tendons in order to employ them as thongs, just as the Esquimaux now use them to stitch their dresses.

M. Lartet, whose acquirements in palæontology are at the same time extended and accurate, has studied much more thoroughly than those who have preceded him, the diluvium and the deposits of the quaternary caverns, and has determined the existence of four periods, marked out by the presence of the aurochs, the reindeer, the cave-bear, and the elephant (E. primigenius). The predominance of the bones of the reindeer in the centre of France, would prove that man has lived in Périgord during one of these periods, but would not weaken this truth, admitted as indubitable by the eminent geologist, that is, that man has been coexistent with other huge quaternary mammalia.

Nevertheless, M. Élie de Beaumont, in referring to one of the very numerous communications on the subject of the caverns which are constantly addressed to the Academy, has protested against this conclusion. For, says he, the more convincing the demonstration of the existence of the reindeer becomes, precisely in the same degree is the insufficiency declared of the supposed proofs of the long-past coexistence of man and the elephant (E. primigenius).

The learned and well-known French geologist cannot admit this contemporary existence, despite the facts and the proofs which seem to be accumulating both in number and weight. M. de Vibray, whose opinion is above suspicion, since, as he says himself, he had at first been a sceptic, has also just brought forward some proofs, having felt himself obliged to yield to the evidence adduced. M. de Lastic has discovered in the grotto of Bruniquel (Aveyrou) a prodigious quantity of bones of the reindeer, of the horse, &c., mingled with human bones, and with objects carved in the form of arrows.

MM. Garrigou, Martin, and Trutat, after examining the débris of the human jawbones found at Bruniquel, have believed themselves warranted in coming to some general conclusion; and in saying that the three jawbones (human) found in the quaternary deposits are to be referred to the brachycephalic type, although they have been met with in different localities by the side of the cavern-bear in the cave of Aurignac, now rendered famous by the tombs and the traces of funeral festivals described by M. Lartet; by the side of the elephant at Moulin-Quignon, and along with the reindeer at Bruniquel. Man then having lived at different dates with animals of various species, appears not the less to have retained his brachycephalic type.

In the grotto of Lourdes, already explored by MM. Lartet and Milne-Edwards, below the layers in which these gentlemen had determined the proofs of the coexistence of man (stone age) and of the reindeer; there should be found, according to a recent communication from MM. Garrigou and Martin, still deeper deposits in which the coexistence of man and of the aurochs would be obvious. In a similar grotto we can then meet with the traces of two distinct ages superposed, one above the other.

MM. Garrigou and Martin have such confidence in the succession of these ages, that in reference to the cavern of the valley of Espalungue, they put forward this positive opinion, that in order to find in this locality the traces of the coexistence of man, of the cavern-bear, and of the elephant (E. primigenius), the search should be made above the cavern, if it is to be attended with any chance of success.

This question of the antiquity of man, only recently so much controverted, is making, as it will be seen, great and rapid progress. We have not mentioned all the labours undertaken, and all the communications made in France, but we may well judge from those which have been referred to, that French geologists have fully appreciated the task which they had to fulfil, and they are giving themselves with a praiseworthy ardour to the study of the soil of their country, so rich in matters relating to races now extinct.

We could not close our notice without acknowledging the readiness MM. Lartet and Christy have shown to communicate their discoveries in the Périgord to the scientific world. After having placed specimens of the highest value from their excavations in the museum of Périgueux, in that of Paris, and having reserved one specially important example for the museum which is being prepared in the Château de St. Germain to receive the beautiful collections presented by M. Boucher de Perthes, and which will be exclusively set apart for illustrations of the history of the antiquity of man;

these gentlemen have forwarded to a large number of the museums of the most important towns of France and of Europe specimens from the excavation of Eyzies.

Whilst he was proprietor of most of the caves which have been explored, Mr. Christy has made the special reservation, that only the *unique* specimens should remain in the country in which they had been found. Is not this disinterestedness above all praise, and does it not prove how thoroughly that antagonism, which petulant minds too often try to foster, between the two first nations of the world, becomes obliterated between men who love science thoroughly and sincerely?

Paris. TH. LACAZE DUTHIERS.

Improved Machinery for Boring Rocks. By George Low.

The last number of the 'Journal of Science' contained a brief reference to my patent boring-machine, in which it was stated that it does not differ materially from others.

In this, your "Chronicler" is under a misapprehension, and I trust I may be permitted to say that my patent machine has many important advantages over those of other makers.

In order to make good this statement, or rather to enable my professional brethren to judge for themselves in the matter, and also because I think that the subject must be one of interest to all classes of readers, I forward to you the following account, illustrated with representations of my boring-machine, and request the favour of its insertion in the Journal.

The cylinder and boring tool of my machine are arranged on a telescopic principle, being only 4 feet 6 inches in length, from end to end, and sufficiently short to swing round in any direction in a tunnel. They are so arranged that they can be set to work in any part of the face, perpendicularly, horizontally, sideways, or at any angle and in any direction, as best suited to the strata, and to meet the convenience of blasting.

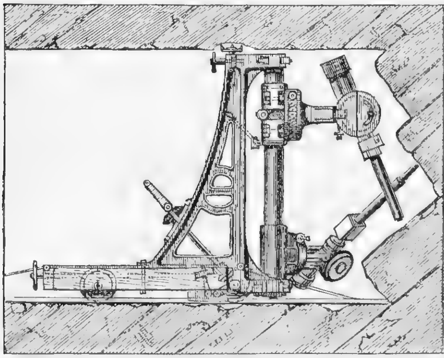


FIG. 1.

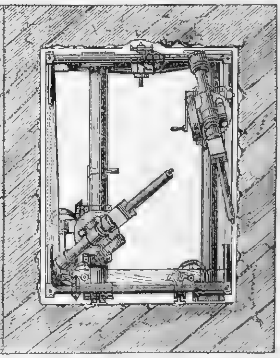


FIG. 2.

In Figures 1 and 2, for instance, which represent a machine adapted for tunnelling, adits, &c., the cylinder is provided with five different movements, and is mounted on a jib, which allows the cylinder and boring tool to be set at any angle, perpendicularly to horizontally; the jib being moved up or down the columns on a screw inside, and the columns can be moved from side to side. The jib is also capable of being swung round the columns, and with the cylinder it can swing round sideways at any angle in front of the columns. Each of these movements is effected by a hand-wheel, and each set of gear is provided with a tightening break, so as to render the whole perfectly steady whilst in operation. The working parts are covered to protect them from the rock-dust and débris.

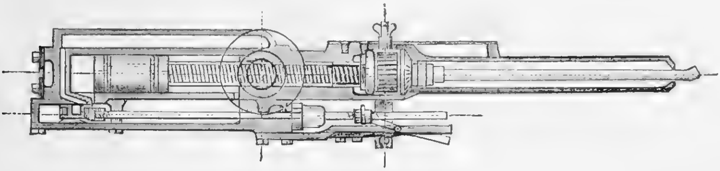


FIG. 3.

Figure 3 shows the cylinder and boring-machine and tool in detail. The chief peculiarities of these are, the shortness of the whole, the fixed cylinder, with telescopic tool, central screw, and parts completely covered. The screw which propels the tool in progress of boring (actuated by a diagonal slot attached to the cylinder by a roller-ratchet wheel) goes up inside the piston-rod, receiving the percussion blows centrally, and thus obviating any danger of the tool leaning to either side.

It will be observed that the cylinder is, as remarked, stationary, the tool and screw being propelled from it in course of boring, instead of a motion being imparted to the cylinder itself. This arrangement allows of *all* the working parts of the cylinder and boring motion being completely covered from rock-dust, wet, &c., which have been found so destructive to boring-machines.

The tool is arranged so that it travels (self-acting) at any rate that may be requisite, proportioned to the hardness of the rock, this being regulated by the position of the

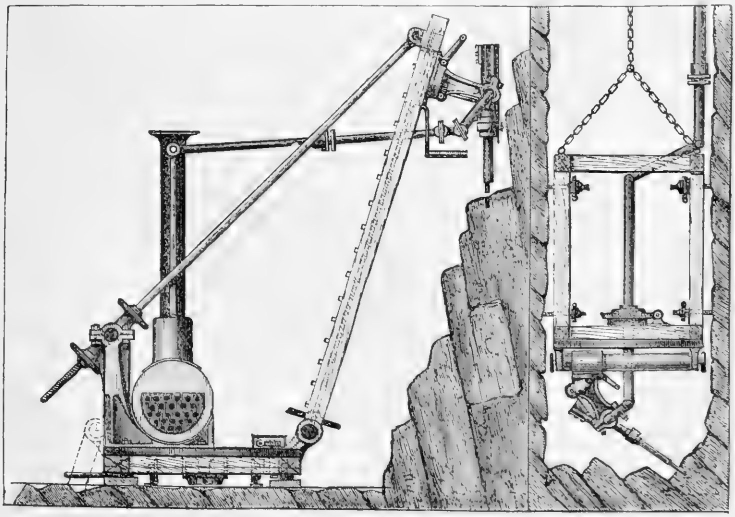


FIG. 4. FIG. 5.

propelling slot. The latter may be placed with a greater or less slope, so as to actuate either one, two, three, or four teeth in the ratchet-wheel, and thus to move the screw more or less quickly.

Figure 4 represents a machine intended for quarries of every description, and Figure 5 is for sinking perpendicular shafts.

With regard to the whole machine, I may add that the carriage frame is provided with a propelling gear, to draw it to or from the face of the rock to be acted on at intervals required for blasting. The various moving gears are so arranged that one man can draw and adjust the borers to work in the necessary direction in a few moments; and the machine may be worked either by compressed air, steam, or water, the first-named being preferable in tunnels, as the escape air provides ventilation. In case steam is used for quarries and perpendicular shafts, it is provided with a condensing apparatus, and the condensed water is injected into the holes at every stroke, whereby these are kept clean. The machines are constructed with carriage frames of different forms, so as to adapt them for driving incline levels, adits, tunnels, perpendicular, slope-face, and flat surface of quarries, open cuttings, &c.; and, according to recent trials, we have been enabled to bore holes with them in hard rocks at the rate of two to four inches per minute.

I trust this brief account may be deemed interesting to your readers.

George Low.

Newark-on-Trent,
June, 1864.

Books received for Review.

From *Mr. John Murray*:—

METALLURGY: the Art of Extracting Metals from their Ores, and adapting them to various Purposes of Manufacture. By John Percy, M.D., F.R.S. Vol. II., 'Iron and Steel.'

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ANCIENT MEOLS; or, Some Account of the Antiquities found near Dove Point, on the Seacoast of Cheshire; including a Comparison of them, with Relics of the same Kinds respectively procured elsewhere. By the Rev. A. Hume, LL.D., D.C.L., &c. (London: J. R. Smith.)

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Revue Universelle des Mines, de la Métallurgie, &c., &c. (Paris & Liege; Noblet & Baudry.)

The Journal of the Chemical Society. (Baillière.)

Edinburgh New Philosophical Journal; concluding number. (A. & C. Black; Longmans.)

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Bulletin Mensuel de la Société Impériale Zoologique d'Acclimatation. (Paris: Masson & Fils.)

Transactions of the Tyneside Naturalist's Field Club. Vol. VI. Pt. ii. Plates. 220 pp. (Dodsworth, Newcastle.)

Annual Report and Transactions of the Plymouth Institution, and Devon and Cornwall Natural History Society. 1862–3.

Annual Report of the Cambridge University Natural Science Society, and Retiring Address of the President.

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Report of the Liverpool Naturalist's Field Club.

Report of the Montreal Natural History Society. (Address of President, Dr. Dawson.)

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THE QUARTERLY

JOURNAL OF SCIENCE.

OCTOBER, 1864.

ORIGINAL ARTICLES.

ON RADIANT LIGHT AND HEAT.

By Balfour Stewart, M.A., F.R.S.

While the progress of knowledge more and more reveals the intimate relationship which subsists between different truths, it may nevertheless be sometimes expedient to set apart for separate consideration some field of science possessing a boundary line which is perfectly natural and definite. The subject of our choice has this advantage. We all know that heated bodies give out a species of influence capable of traversing space with enormous velocity, and in virtue of which the eye is enabled to perceive the sun and stars. Science further informs us, that such bodies emit also non-luminous rays, some of which have a chemical virtue, and all, including also the luminous ones, have the power of heating those substances upon which they fall and whereby they are absorbed.

The remarks we are now about to make are capable of extension to the whole of this complex radiation, but we have preferred to embrace them under the term Radiant Light and Heat,—a title which, although not complete, yet recalls those properties of rays with which we are most familiar.

Our limited space will not, however, permit of our discussing more than one of the many interesting problems presented by this subject for our consideration.

An idea very generally adopted until lately, was that which regards a luminous body as discharging through space innumerable particles of exceedingly small magnitude with the almost incredible velocity of nearly 200,000 miles per second. But objections of a very formidable nature have gradually gathered around this view, until it has been generally abandoned, and light is now rather considered as an undulation which is propagated in all directions from a luminous centre, through some very attenuated medium pervading space. Accepting this view of the case, let us now briefly inquire into the nature of these waves, ascertaining also how this is modified by the various qualities of those bodies which give rise to luminous rays, as well as by the qualities of those other bodies whereon they fall.

If we fasten one end of a long cord to a peg, and holding the other end not too tightly in the hand, then strike the cord with a rod, we shall perceive that the blow causes an agitation, which travels along the cord with a progressive motion. We shall also at once comprehend that this *something* which travels is not a substance but a form, and that it is similar in this respect to that appearance which sweeps across a field of corn on a windy day. Our readers will obtain a very good idea of the undulations which constitute light, if they suppose them similar to the waves that travel along such a cord.

So much for the nature of the light-waves; let us now consider their length. Wave-length, or the distance between the crest of one wave and that of its neighbour, is a term which explains itself. Anyone who has witnessed the phenomena of the ocean, or even of a pool of water, can have no difficulty in comprehending what this means. If a stone be dropped into a pond, the space between two consecutive circles of agitation affords a measure of the wave-length, which is, however, very small as compared with the distance between two great ocean waves. In the theory of sound the wave-length is an important element, and determines the pitch of the note; the rule being, that by descending one octave you double the wave-length. Now, what have we in optics analogous to pitch in a musical note?

Colour will at once be recognized; and we shall all be prepared to find that the wave-length of a ray of light determines its colour, and that red, orange, yellow, green, blue, violet, &c., have each their appropriate wave-length. We need hardly remind our readers that a ray of sunlight contains, blended together, not one but many of these wave-lengths; for we all know that many colours go to form white, and we are no doubt familiar with the method by which a ray of white light may be decomposed into its many-coloured components. Nevertheless, as this is a subject of very great importance in the present inquiry, we may be allowed to discuss it at some length. Newton was the first to show that a ray of white light is, in reality, compound, and his fundamental experiment may be thus described. Let us take a glass prism, and place it in a vertical position.

Fig. 1.

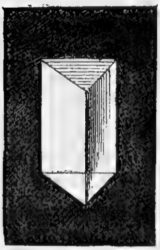


Fig. 2.

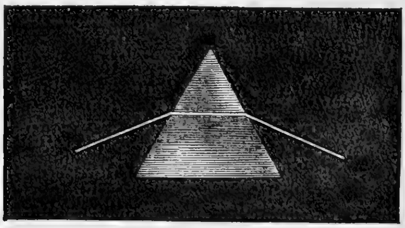


Fig. 1 represents an elevation, and Fig. 2 the ground plan of such an arrangement. Now, let a ray of light, as in Fig. 2, strike obliquely against the side of the prism, enter it, and pass through. It will be greatly deflected by this process, so that its line of exit will differ very much in direction from that of incidence. This is sufficiently well shown in our figure, but there is yet something more. All rays are bent, but rays of one colour are deflected differently from those of another. If, now, the ray which impinges upon the prism be a single one of white light, that which leaves it will be no longer a single ray, but rather a pencil of rays, in which we shall obtain, in a separated condition, all those colours which together constitute white, because each one has been bent in a different direction.

We may now easily comprehend what is meant in optics by the term "Spectrum." In order to do so let us recall before us the ordinary photographic camera, not however to be used in obtaining the likeness of a landscape or of a friend's face, but only that of a slit illuminated by white light. If our arrangement be the ordinary one, we shall of course obtain as an image on the screen which is placed in the focus of the camera a single line of light; but if we interpose a glass prism between the illuminated slit and its image, each individual colour which goes to form white light will be bent in a different direction by this prism, and will give rise to an image that will be thrown upon a different part of the screen. Instead therefore of having one image of the slit of light upon the screen, we shall in reality obtain a number, each having its appropriate colour. The image will, in truth, form not a line at all, but rather an oblong space differently coloured at each part. This oblong illuminated coloured space is called a "spectrum;" and if the line of light whose image we are viewing be that which proceeds from a slit illuminated by the sun, then we shall obtain the solar spectrum.

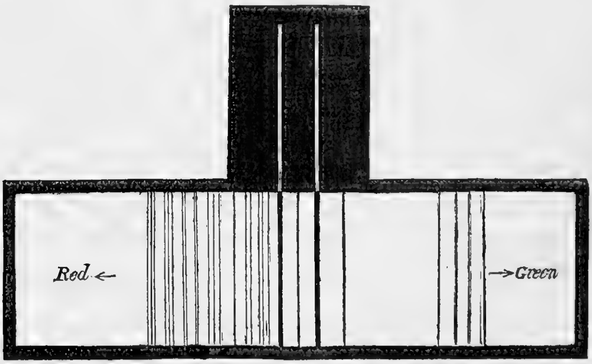
Let us arrange so that those rays which are least bent may lie to the left, and those most bent to the right, and we shall then have colours proceeding in the following order from left to right: *viz.* red, orange, yellow, green, blue, indigo, violet. Red therefore is the least, and violet the most, refrangible ray; but at the same time the wave-length is greatest towards the left, that of red being about $\frac{1}{37000}$, while that of violet is only $\frac{1}{64000}$ of an inch. We thus see that light-waves are extremely small as compared with those of sound, and also that there is hardly one octave comprehended in the visible spectrum, since the wave-length of violet is rather more than half that of red.

But while this embraces the whole of the visible solar spectrum, we yet know by means of the thermometer that there is a very considerable heating effect to the left of the red, thus denoting the presence of invisible rays; and we likewise know, through certain experiments which we cannot here detail, that the spectrum extends very much to the right of the violet, the invisible region in this direction being chemically powerful although its heating effect is but small. We now come to a very curious fact, first pointed out by our countryman Wollaston and afterwards by Fraunhofer. It is found that the solar spectrum does not contain every possible ray, from the red at the one end to the violet at the other, but that the appearance it presents is that of a luminous ground crossed by black lines, which denote the absence of certain rays.

The origin of these lines was for a long time a most perplexing question. Sir David Brewster was the first who prepared the way for its solution, by showing that analogous (not identical) lines might be artificially produced by interposing a jar containing nitrous acid gas in the path of the ray. His inference was that the solar lines do not denote rays originally wanting in the light of the sun, but are due rather to the absorption produced by some substance interposed between the source of light and the spectator. His subsequent researches in conjunction with those of Dr. Gladstone and others led, on the whole, to the belief that this absorption was probably not due to the earth's atmosphere, and of course the only remaining field for such an influence was the atmosphere of the sun. But it remained for Kirchhoff, a distinguished German philosopher, to set the matter at rest, not however before the true explanation had been divined by Professor Stokes. This belongs to another part of our subject: in the meantime we shall describe what has been already accomplished in delineating these wonderful phenomena, the lines.

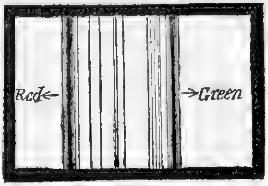
In the solar spectrum, as in the starry firmament, every new accession of magnifying power enables us to reap a fresh harvest of discovery. Thick lines split themselves up into a bundle of thin ones; nebulous bands resolve themselves into distinct lines; new groups spring into existence, and the appearance of things is so entirely altered, that an observer accustomed to a small instrument would not be able to recognize those very parts of the spectrum with which he used to be most familiar. This cannot be better exemplified than by referring to the double line known as "D," a prominent line between

Fig. 3.



the orange and the yellow. Fraunhofer only just succeeded in recognizing its duplicity. Kirchhoff, in his admirable map of the spectrum recently published, a small portion of which is represented in Fig. 3, has drawn it as the two strong lines with a faint one between, shown in our cut. Professor Cooke, of America, has still further filled up the intervening space, while very lately Mr. Gassiot, by his magnificent spectroscope of eleven sulphuret of carbon prisms, has obtained the appearance presented in Fig. 4.

Fig. 4.



In order to give our readers an idea of the amount of separation between the different kinds of light produced by the prism, we may mention that Kirchhoff lengthens out the visible spectrum into 8 feet, while a map is being prepared at Kew Observatory from Mr. Gassiot's spectroscope, which, when finished, will probably attain the very great length of 24 feet. But even with instruments of the highest power, we yet perceive nebulous bands in the spectrum, which a still higher power might not improbably resolve into lines; just as with Lord Rosse's telescope we observe nebulæ in the heavens which a higher power might possibly resolve into stars.

Spectra of the fixed stars have likewise been obtained by several observers. Fraunhofer noticed that the double line D was present in some of these. Secchi, Airy, and others, and more lately Huggins and Miller, have obtained the spectra of several stars. The last-mentioned observers, in particular, have furnished detailed maps of those of Aldebaran, Alpha Orionis, and Beta Pegasi. We shall return again to this subject, but in the meantime we may remark that the general character of stellar spectra is a luminous ground intersected by dark lines, many of which are identical with lines in the solar spectrum, while others however are different.

But we must not omit to mention the appearance presented by the spectra of heated vapours. Electricity and other agents enable us to obtain the vapours of metals and other bodies at an extremely high temperature, and when the rays which these emit are analyzed by the prism in the way already mentioned, we have results which are exceedingly curious. The metal sodium, or any of its compounds, such as common salt, produces a flame which is intensely yellow; and this flame, when analyzed by the prism, is found to consist of two simple rays exactly corresponding in position with the two lines D. We are thus furnished in the salt flame with two rays which are absent in the light of the sun, and with these rays alone, for there is not a vestige of any other, and we have a perfectly dark ground—the appearance being that of the upper portion of Fig. 3. Again, when the vapour which we examine is that of iron, we have as before bright lines on a dark ground, and these have been found by Kirchhoff to coincide with certain dark lines in the solar spectrum. Generally speaking, all heated vapours give spectra, consisting of bright lines scattered over a dark space, but in many of these the bright lines have not as yet been found to coincide with dark solar lines. It has been shown by Bunsen, Kirchhoff, and others, that these bright lines are always characteristic of the vapour which is ignited to produce them. Each elementary substance has its peculiar lines, and probably no line of any one element is exactly coincident with that of any other. We are thus furnished in the spectroscope with an exceedingly delicate test of the presence of any substance. We have only to pass the electric spark through the body which we wish to analyze, and the sudden flash perceived is in reality a small portion of the vapour of that body in a state of intense ignition. If we analyze this by the spectroscope, we shall obtain lines that will enable us to determine the substance employed. So delicate is this method, that we can detect with ease the presence of quantities of a sodium salt less than $\frac{1}{200,000,000}$ of a grain in weight. Nor is it valuable only for substances with which we are familiar, but it has also been the means of our discovering new elements. The metals Cæsium and Rubidium were thus discovered by Bunsen; Thallium, by our countryman Crookes; and Indium, by Messrs. Reich and Richter.

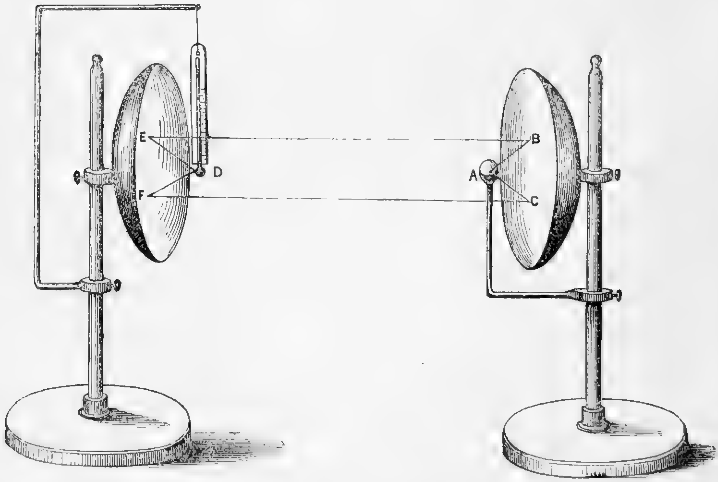
So much for ignited vapours. On the other hand, the spectra of incandescent opaque solid or liquid bodies, or of all bodies of very great thickness, are continuous throughout, and consist of a bright space, varying in colour from one portion to another, but without lines. We have thus three varieties of spectra.

First. Solar and stellar spectra, exhibiting a bright ground interspersed with dark lines.

Secondly. Those of heated vapours, consisting of bright lines on a dark ground.

Thirdly. Those of opaque, solid, and liquid bodies, consisting of a continuous brightness without lines.

FIG. 5.



We must now request our readers to accompany us to quite a different part of our subject, although in the end we hope to trace its connection with that which has preceded.

Towards the latter part of last century Professor Pictet, of Geneva, performed a curious experiment which appeared to prove the reflexion of cold. He placed two polished metallic concave reflectors facing one another, as in Figure 5, and while in the focus of the one he put a thermometer, in that of the other he placed a lump of ice, the effect of which was to lower the temperature of the thermometer. At first sight this result would seem to indicate that cold is something more than a mere negation, and indeed that it is an influence susceptible of radiation and reflexion in the same manner as heat. It soon, however, occurred to Professor Pierre Prevost, of Geneva, that this was by no means a necessary conclusion, and this sagacious reasoner proposed, as an explanation of the experiment, the theory of Exchanges, or, as he termed it, a movable equilibrium. In order to comprehend this definition, let us suppose that we have a room walled in on every side, and that its walls, including the floor and ceiling, have the temperature of 60° Fahrenheit. Now in whatever part of such a room a thermometer is placed, it will ultimately attain the temperature of the walls; that is to say, it will indicate 60° Fahrenheit, after which the mercury will neither rise nor fall, and there will be an equilibrium of temperature. When this has happened one of two things must be taking place. Either the thermometer does not give out radiant heat, or if it does it receives back continually just as much as it gives out. Prevost supposes the latter to be the case, and that all bodies even of the same temperature are continually giving out heat to one another, and receiving in return just as much as they give out. Therefore, according to his theory, a body will fall in temperature when it radiates or gives out more heat than it absorbs, its temperature will be constant when the radiation and absorption are equal, and will rise when the absorption is greater than the radiation.

Let us now see how this idea will explain Pictet's experiments. By this theory, although the bulb D is of the same temperature as the reflector E F, yet there is a constant interchange of heat between them. Hence rays of heat will leave the bulb in the direction D E and D F, and these will finally be reflected upon A. The body A is however giving out rays in return, which finally fall upon D. But since A is colder than D, the rays which leave D and fall upon A are more intense than those which leave A and fall upon D. The consequence of this will be that on the whole there will be a transference of heat from D to A, and the temperature of the thermometer will fall. And this transference from D to A will be just as much intensified by the reflectors as that from A to D would have been had A been hotter instead of colder than D.

Thus we see how easily the observation of Pictet is accounted for by the principle of exchanges—a principle which soon exhibited all the marks of a true theory by explaining facts as they were elicited by experiment, and at the same time by suggesting new truths, in which latter aspect more especially it has been of very signal service to science. But it is not our intention to give the history of this problem; let us rather remark its more interesting and important applications. Let us for this purpose imagine a red-hot chamber having the temperature of 1,000° Fahrenheit, the sides of which are composed of every variety of substance from polished metal to lamp-black. Let us place in this room a suitable instrument for measuring temperature —call it a thermometer—it is clear that in whatever part of the room we place this instrument it will always denote 1,000°, since all the walls are of that temperature. Let us bring our thermometer near to the polished metal, it will still denote 1,000°. Now the rays which reach the thermometer from the polished metal are twofold. First, there are those given out by the metal itself since it is red hot; and secondly, there are those which it reflects from the lamp-black surface beside it. But this twofold supply of heat from the polished metal, partly given out and partly reflected, will be *too much* for the thermometer, unless it happens that the metal, in virtue of the heat which it reflects, gives out so much less on its own account. This is found to be the case, and it is very easy to convince ourselves by experiment that a reflecting body when heated gives out little light. Let us take a piece of platinum, partly polished and partly tarnished, heat it to a white heat and then immediately examine it in the dark. We shall find that the polished portion is much less luminous than the tarnished. Or, in like manner, let us heat some lead or tin to a good red heat, and then take the vessel containing it into the dark; if we skim its surface with a red-hot iron spoon we shall find that the heated metal underneath is much less luminous than the dross. We may vary the experiment by heating a piece of porcelain of a black and white pattern, and examining it in the same manner, when we shall find that the black is much more luminous than the white, the reversal of the pattern producing a very curious effect.

But let us return again to our chamber, and now suspend in a vertical position, near one of the walls, a sheet of transparent colourless glass, leaving it, of course, for a sufficient length of time to enable it to acquire the temperature of the chamber. Let us place our thermometer in front of this plate. Now, the plate being transparent will permit to pass through its substance all the red heat from the wall behind it: if, in addition to this, it gave out a great deal on its own account, we should have, just as in the previous case, a twofold supply of heat falling upon the thermometer, so that its temperature would rise above that of the chamber. Since this cannot be the case, it follows that transparent glass will give out very little red light on its own account when heated to redness. We may verify this for ourselves by taking various pieces of glass, some colourless, and others more or less coloured; let us heat them to a good red heat, and examine them in the dark. It will then be found that a colourless piece gives out very little light, while a highly-coloured or opaque specimen gives out very much. The law may be stated thus:— a body which absorbs much heat will also give out much on its own account when heated.

But one important fact yet remains behind. Let us revert to the plate of glass suspended in the red-hot chamber, and suppose this plate to be of such a colour as to stop all the red rays that reach it from the wall behind. We have already seen that, if it stops a good many rays, it will give out a good many. We have further to observe, that the rays it gives out must be precisely of the same kind as those which it arrests: it stops the red rays. Now, if it give out dark heat, but not red, then, looking towards the glass, we shall get no light from it, since it stops the red rays from behind, and gives out none of its own. But this is evidently impossible in a red-hot chamber, for universal experience teaches us, that any substance left in such a chamber will ultimately appear red hot. If, therefore, the glass be of such a nature as to stop any particular ray of light or heat, it will, when at a high temperature, give out on its own account that very ray. This may be exemplified by several very simple experiments. Take a piece of ruby glass, coloured with gold. This glass, as its name sufficiently denotes, allows all the red rays to pass, but stops the green. Heat it in the fire to a good heat, and examine it in the dark, when it will be found to give out greenish rays. On the other hand, green glass (which stops red rays) will, when heated, give out a dark-red light. These curious facts may be noticed at any place where coloured glasses are spun. Another good illustration of this law is obtained by putting a number of differently-coloured glasses into the fire, and it will be found that they all appear to lose their colour when they become of the same temperature as the coals around them. Not that the glasses have changed their nature in the least, for the red glass still stops the green, and the green glass the red rays, from the coals behind; but each glass gives out, on its own account, precisely those rays which it stops, so that the light (transmitted and radiated together) which comes from the glass is just the same as would have come from the coals alone.

Kirchhoff has beautifully extended this law to those individual rays which compose the spectra of luminous bodies. We have already stated that the spectrum of sodium consists of two bright lines D, and in general that the spectrum of a heated vapour consists of bright lines on a dark ground. Now, if instead of using these vapours as our source of heat, we use them in a comparatively cold state as a screen, our source being an incandescent solid body which gives out all rays, then we shall find that each vapour stops precisely those rays which it gives out when heated. Thus, a salt flame, or incandescent sodium, gives out the double line D; vapour of sodium (when cold) also stops the same line, and a similar rule holds for all vapours. Whenever, therefore, we have a source of light containing all rays, but which is surrounded by an atmosphere of metallic vapours at a low temperature, each of these vapours will stop its own appropriate rays, and the spectrum of such a system will exhibit a bright ground intersected by dark lines. This is precisely the character of the solar spectrum, and we have seen that one of its lines, namely D, is that which is produced by the absorptive power of sodium vapour. We are therefore entitled to conclude that this vapour exists in the atmosphere of the sun. Again, the vapour of iron gives out certain bright lines which appear as dark in the sun's spectrum, we conclude therefore that iron vapour exists there in a *comparatively* cold state; and in like manner we find that a number of the solar lines are due to the presence of nickel, and that calcium, magnesium, barium, copper, zinc, all well-known substances, are suspended in the atmosphere of our luminary. By a similar process, sodium, magnesium, hydrogen, calcium, iron, bismuth, tellurium, antimony, and mercury, have been found in Aldebaran, and other elements in other stars.

We have thus arrived at the wonderful result that many of these substances with which we are most familiar occur also in the sun and stars, and the great law which has led us to this conclusion may be stated thus :—a body absorbs those very rays which it gives out when heated. Let us now see if we have not a similar law in other branches of science. When a musical note is sounded in the presence of a string which would give out the same note, the string catches up or absorbs the musical note in order to give it out on its own account. We may place the two laws side by side in the following manner.

A body when cold absorbs the ray which it emits when heated. A string when at rest catches up the note which it gives out when struck. Nor perhaps are we without an indication that the same law holds in medicine. *Similia similibus curantur* (like cures like) is the doctrine of a certain school; but we leave homœopathists to follow out the analogy here suggested.

We have offered these observations in order to show our readers that the law which we have endeavoured to place before them is one whose foundation lies very deep in the present system of things: and the result that Kirchhoff has deduced from this law is one altogether worthy of its greatness; a result bringing vividly before us the *oneness* of the universe, inasmuch as it discloses the prevalence throughout the solar and stellar systems of those very forms and species of matter with which we are here familiar. No fact hitherto discovered so much exhibits the unity of creation—none more the unity of the Creator; and thus the last great achievement of science becomes as it were a comment on the first page of Sacred History, in which we are told that "He made the stars also."

ON THE SOURCE OF LIVING ORGANISMS.

By James Samuelson, Editor.

There are two subjects in Natural History which, more than any other, attract the attention of modern biologists, — the Origin of Species, and the Source from which the lowest known Forms of Life are derived; in other words (reversing the order of subjects), the Beginning of Life, and its Continuance.

To those persons who have followed the discussions relative to these two inquiries, it is quite obvious why they should simultaneously occupy the attention of the scientific world, for it has with truth been observed, that an earnest advocate of the Darwinian theory, one who teaches that every living form is and has been the result of a modification of some lower and preceding form of life, brought about solely by secondary causes, cannot halt midway in his teaching, and be content to hold that life began with four or five primitive types, such as he may be able to trace in the lowest inhabited strata; he must carry his investigations still further, and must account satisfactorily for the appearance of life-endowed beings in any shape, before he can be said to have fully established his position.

It is in this spirit that the inquiry is now prosecuted; and those who take a deep interest in the subject, do so, not as formerly, for the purpose of ascertaining from what source a particular group or species of animals is derived, but with an earnest desire to obtain some knowledge as to the conditions under which life is first manifested on the earth's surface. Nor is the consideration of the subject confined to the ranks of biologists only, for some of the most important discoveries have already been made by chemists and physicists, and it is more than probable that the solution of the problem (should that follow in the course of time) will be due to the joint researches of men engaged in the study of these various branches of science, every one of which cannot fail to be indirectly benefited by the investigation.

Probably the attention of reflecting observers was first directed to the subject of the origin of living beings through the mysterious appearance, in the decaying bodies of animals and elsewhere, of the larvæ of insects; and the earliest treatise of any note on the subject was most likely that of Redi, 'De Generatione Insectorum,' Amsterdam, 1686, up to whose time it was currently believed that decaying substances became converted, during their decomposition, into insects and some other forms ranking below them in the animal scale. This is called "spontaneous generation."

After the publication of Redi's researches on the mode of reproduction in insects, the theory of abnormal generation was for a time discarded; but about sixty years subsequently, in 1745, Needham revived it in a work published in London, entitled 'New Microscopical Discoveries;' and, on the other hand, about fifty years after that, another observer, Spallanzani, an Italian, attempted to disprove the existence of "spontaneous generation" by experiments and philosophical induction. He sought to show that animalculæ which make their appearance in decaying organic substances are not accidentally generated by the reconstruction and reorganization of such matters, but that their ova, or germs, exist in the atmosphere, and being conveyed into the decaying substances, find in them a suitable pabulum, and thus become developed. He stated that if the air is excluded from such substances no animalculæ make their appearance.

This was the state of the discussion sixty or seventy years since; and although considerable progress has no doubt been made in the inquiry, the field of research being necessarily more restricted than formerly, inasmuch as every day the appearance of some form or other is accounted for without any appeal to "spontaneous generation," still the elements of the dispute remain much the same as they were, and the chief efforts of investigators are directed to the proof or disproof of the existence of the germs of living beings in the atmosphere.

The clearest and most tangible exposition of the views of those who formerly advocated the theory of heterogenesis, or abnormal generation, is to be found in Todd and Bowman's 'Cyclopædia of Physiology,' in the edition published in 1839;* and it will be found useful for our purpose to extract some of the writer's remarks, inasmuch as they will show the student of to-day how the recent revelations of science have struck away, one by one, the props upon which the doctrine was based, and have so reduced the inquiry within the narrowest limits.

"The following considerations appear to us to throw the balance of evidence in favour of the spontaneous production of infusoria, mould, and the like. Firstly, those organic matters which are most soluble in water, and at the same time most prone to decomposition, give rise to the greatest quantity of animalcules or cryptogamic plants. Secondly, the nature of the animalcule or vegetable production bears a constant relation to the state of the infusion; so that, in similar circumstances, the same are always produced without this being influenced by the atmosphere. There seems also to be a certain progressive advance in the productive powers of the infusion, for at first the animalcules are only of the smallest kinds, or monads, and afterwards they become gradually larger and more complicated in their structure: after a time the production ceases, although the materials are by no means exhausted. When the quantity of water is very small, and the organic matter abundant, the production is usually of a vegetable nature; when there is much water, animalcules are more frequently produced. Thirdly, on the supposition that infusory animalcules are developed from ova, it is necessary to conclude, from the experiments already referred to, that these ova are in some instances derived from the atmosphere; but yet the number of infusoria is by no means in proportion with the quantity of air. We are also reduced to the necessity of holding that every portion of the atmospheric air is equally impregnated with infusorial germs or ova, and that these bodies may remain for years dissolved, as it were, or invisibly suspended in the atmosphere, and in a perfectly dry state,—a supposition contrary to analogy, and not fully warranted by the fact that vibriones may be resuscitated by means of moisture after they have been kept in a dry state for long periods. Fourthly, it may be remarked that the existence of ova, as belonging to many of the infusoria, is entirely hypothetical, since most of these animals are known, when once formed, to propagate by other means, as by the division of their whole bodies, or by budding."

If the writer of these remarks had been aware when he penned them (and we hope he still lives to witness the results of scientific progress since his observations were made), that the same general laws which regulate the growth and development of the higher animals are found to operate very low down in the scale, he would not have leaped to such conclusions. The rapid increase of animalcules in substances "most prone to decomposition," would merely have satisfied him that the abundance or scarcity of living forms in infusions was

* In which the student will also find additional information concerning the history of the controversy.

in proportion to the amount of nourishment afforded to them; and in the appearance of certain characteristic types in particular infusions, he would have recognized the operation of the law which causes every plant (speaking in general terms) to be peopled by its appropriate parasite. His statement that the same animalculæ are always found in similar infusions, is however only partially correct, and, as it will be shown hereafter, is far from being a correct phenomenon.

Next, as regards the "progressive advance in the productive powers of the infusion," the appearance in fact of successive generations of living forms rising in the developmental scale, in one and the same infusion. An acquaintance with the phenomena of the "alternation of generations," and a little reflection upon the fact that "Monads" may grow into ciliated infusoria whilst the eye of the observer is engaged otherwise than in their examination, would have materially shaken the writer's faith in the "productive powers" of the infusion.

The researches of my esteemed coadjutor, Dr. Balbiani, of Paris, have set at rest the question of the existence of ova in the infusoria, for he has shown that in addition to the other processes by which they multiply, these forms possess also the sexual elements common to all animals.*

The only question, therefore, of any importance to which a satisfactory reply is required, is the one already referred to:—Do the germs of infusoria, or do they not, exist in the atmosphere in sufficient quantities to account for their entrance into infusions?

Before proceeding to consider this vital question, however, it is right that I should touch upon a phenomenon referred to by the writer in "Bowman" in another part of his article, and thrown by him into the scale in favour of the theory of heterogenesis. That is, the appearance of entozoa, or internal parasites, in the tissues (or, as he says, the bodies) of living animals. This is really a most difficult problem to solve, but we never hear it mentioned at the present day even by the advocates of heterogenesis. The presence of some of these parasites is still a great mystery, on which a partial light only has been thrown by the recent researches of zoologists in regard to the transformations that such forms undergo in their passage from one animal into another, from the prey into the stomach, and then into the vascular, or other systems of its devourer. As already observed, the advocates of the doctrine under consideration do not now affirm that any of these forms are spontaneously produced from the living tissues in which they are found; and I believe that at no very distant period their presence will be, in all cases, fully accounted for.

The chief investigators who have recently asserted that the germs of living beings do *not* exist in the atmosphere, or that they exist only in such small quantities as to render it impossible that the swarms of animalculæ which appear in infusions should be derived from that source, are—Messieurs. Pouchet, Jolly, and Musset (France); Dr. Jeffries Wyman, of Boston (America); Schaffhausen

* 'Recherches sur les Phénomènes sexuels des Infusoires,' par le Docteur A. Balbiani. Paris: Masson. 1863.

(Germany); and Mantegazza (Italy); whilst amongst those who maintain that the atmosphere is the chief source from which such forms spring, are—Schultze and Schwann, and Schrœder (Germany); Pasteur and Quatrefages (France); and there are many other biologists of note who accept the latter view, but whose conclusions are based rather upon induction than experiment.

Taking first the views of the believers in heterogenesis, we have those of Dr. Pouchet, of Rouen, whose investigations, it cannot be denied, have been very elaborate and persevering. He finds in the dust of the air, "the detritus of the mineral crust of the earth, animal and vegetable particles, and the minutely divided débris of the various articles employed in our wants;" but he says (after narrating what kind of animal *remains* he has found, these being unimportant in our inquiry), "twice only in more than a thousand observations, have I observed one of those large ova of infusoria having a diameter of 0,0150 m.m., denominated by naturalists 'cysts.'"* Amongst the numerous experiments tried by Dr. Pouchet, in order to satisfy himself that the "ova" of infusoria do not exist in the atmosphere, is the following:†—

"By means of an inhaling flask, I caused 100 litres of air to pass through a safety tube, whose bulb contained two cubic centimetres of distilled water. At the end of eight days I was unable to discover a single animalcule or ovum in this small quantity of water, in which the latter themselves could not escape observation, now that they have been completely described and measured, and are well known in several species.‡ On the contrary, if I place in a cubic decimetre of distilled water five grammes of fermentable substance, sheltered by a bell glass having a capacity of one litre, at the end of eight days, and at a temperature of 18° C, the whole surface of the water is occupied by incalculable myriads of animalcules."

It would be impossible to follow Dr. Pouchet through his experiments, all of which lead him to the conclusion that "spontaneous generation" is the sufficient and sole explanation of the appearance of Protozoa in infusions; suffice it to say that he has examined the air of towns and of mountain heights, the dust from ancient temples and subterranean sepulchres, and nowhere has it yielded him the slightest evidence of "panspermie;" the universal diffusion of living germs.

Of Messieurs Jolly and Musset it is only necessary to say, that they have recently been the coadjutors of Dr. Pouchet, and that they testify fully to the accuracy of his statements.§

Leaving for a time the ranks of the champions of "spontaneous

* 'Comptes Rendus,' March 21, 1859: translated in the 'Microscopical Journal,' 1860, p. 130.

† *Loc. cit.* p. 134.

‡ I presume Dr. Pouchet refers to "cysts," for Balbiani's discoveries were not published until two years afterwards.

§ They also tried some independent experiments, which will be found described in the 'Microscopical Journal,' new series (1861), p. 47, to prove that "spontaneous generation" may take place in the infusions inserted in the cavities of fruits. I must leave the consideration of these to scientific judges, but do not deem them sufficiently important for transcription here.

generation," we shall now enter those of its opponents, and briefly consider their investigations.

In the year 1837 two German observers, Schultze and Schwann, endeavoured to show that the germs of infusoria *do* exist in the atmosphere, and that when means are taken to destroy these germs before the air in which they are suspended reaches the infusion, no animalculæ appear in it, even after a lapse of some weeks. By means of an apparatus consisting of a flask and tube, provided with bulbs which contained sulphuric acid and caustic potash, they submitted the air to a kind of purification (from animal germs), before allowing it to play upon the infusion; and they asserted that infusions which had been subjected to the influence of air thus treated, showed no signs of animal life even after two months' exposure, whilst others that had been freely exposed to atmospheric influences contained innumerable infusoria.

More recently, Schrœder, a German chemist, arrived at the same results by a different method, and one that appears to me to be more conclusive; inasmuch as it might be advanced by the advocates of the theory of "spontaneous generation" that the same chemical and physical agents (for in some cases the air has been heated to an extreme degree) which are said to destroy the germs of living forms in their passage to the infusion, might also render the atmosphere unfit to sustain life on any terms. Schrœder then* filtered the air by passing it through cotton wool, and found that when infusions which had been previously boiled were exposed to the atmosphere thus filtrated, no decomposition took place. This result he believed to be owing to the fact that ebullition destroys the germs which would otherwise be contained in the infusion, whilst the cotton wool prevented the access of fresh germs with the atmosphere. In this manner he accounts for the preservation of fruits, &c., which are boiled and then covered with bladder or other materials that serve to filter or exclude the air.

The experiments of this observer (which have not, I think, been sufficiently acknowledged by those who have availed themselves of his experience) I have myself repeated with scrupulous care, and the result has been that although I cannot fully confirm what he says in regard to the *entire* absence of Protozoa in infusions which have been protected by cotton wool, yet I can attest that their numbers and proportions, as compared with those in infusions freely exposed to the atmosphere, have been so insignificant as to leave me in no doubt as to the truth of the general principle which he has enunciated.

We now come to the researches of M. Pasteur, a French chemist of great celebrity, upon whose experiments such stress has been laid by certain English and French biologists, that they were regarded as having given a deathblow to the doctrine of "spontaneous generation," and to have proved beyond a doubt that the germs of protozoa are held suspended in the atmosphere.

Whilst conducting some experiments on the origin of ferments, M. Pasteur found in an infusion of yeast, "certain corpuscles, whose form, volume, and structure show that they are organized after the

* 'Annalen der Chemie und Pharmacie,' vol. cix. p. 35.

manner of the infusoria or of the spores of Mucidineæ;" * and was induced through this discovery to undertake certain experiments, one of which we find thus described in a paper read before the Academy of Sciences:†—

"In a series of flasks, containing 250 cubic centimetres, the author introduces the same putrescible liquid,‡ in quantity sufficient to occupy about a third of the total volume of the vessel. The necks of the flasks are drawn out in the spirit-lamp and the liquid is made to boil, the slender extremity of the neck being closed during ebullition. A vacuum is thus produced in the flask. He" (the experimenter) "then breaks off the points in a given locality. The air enters with violence, drawing along with it all the dusty particles it may hold in suspension, and all the principles, known or unknown, associated with it. The flask is then immediately closed with the blowpipe, and placed in a stove heated to 20° or 30° C. (70° to 85° Fahr.), that is to say, in the best condition for the development of animalcules and mucores. The results of the following experiments are not in accordance with the principles generally admitted, but they are perfectly in agreement, on the other hand, with the idea of a dissemination of germs. In most cases in a few days the liquid begins to decompose, and in the flasks, although they may be placed in identical conditions, organisms of the most varied kinds will be seen to arise, far more varied, in fact, especially as regards the Mucidineæ or Torulaceæ, than would have been produced if the liquids had been exposed to the common air. But on the other hand it often happens several times in each series of experiments, that the liquid remains absolutely unaffected, whatever may be the duration of its exposure in the stove, and just as if it had been filled with air that had been exposed to a red heat."

M. Pasteur infers from the latter fact, that it is possible to find in certain localities a given quantity of air which contains no germs;—his general conclusion being, however, as the reader will have observed, in favour of a diffusion of germs through the atmosphere. He also tried other experiments, in which various measures were adopted to intercept the germs in their passage to the infusions (on a similar principle to that employed by Schrœder), and his previous conclusions were verified by the results.§

But Pasteur's experiments, satisfactory and conclusive as they may have appeared to some naturalists, have by no means passed unchallenged. Dr. Jeffries Wyman, of Boston, repeated them, as well as those of Schulze, with, as he affirms, precisely the opposite results; and found that in cases where every precaution had been taken to *exclude* germs from his infusions, they made their appearance after a few days. The vessels were opened in the presence of Professor Asa Gray, and in them were found *chiefly* the very lowest known forms;

* 'Comptes Rendus,' May 7, 1860: translated in the 'Microscopical Journal,' 1860, p. 255.

† 'Comptes Rendus,' Sept. 3, 1860: translated in the 'Microscopical Journal,' April, 1861.

‡ Albuminous water from the yeast of beer; albuminous water containing sugar, urine, &c.

§ He even went so far as to "sow" the germs intercepted by cotton wool in infusions which had before been unproductive of infusoria, and stated that animalculæ then made their appearance.

but mention is made also of "colpoda-like bodies, having ciliary motion."

Still more recently, too, a trustworthy observer at Oxford, Dr. Gilbert W. Child, communicated to the Royal Society the account of a series of experiments, twenty in number, performed with various infusions and a great variety of gases; and although the author modestly states that no definite conclusion can be drawn from so limited a range of experiments, "it is worthy of remark," he says, "that organisms were found here under the precise circumstances in which M. Pasteur states that they cannot and do not exist;" and, he adds, that "the very abnormal conditions under which some of these so-called organisms are found, would render it doubtful whether bacteriums, vibrios, &c., ought to be considered as independent organisms in any higher sense than are white blood-corpuscles, pollen-grains, mucus-corpuscles, or spermatozoa."*

Due allowance being made for the brevity necessitated by the limited space at my command, I believe that my readers have had presented to them a faithful and unbiassed review of this controversy concerning the origin or derivation of living organisms.

A large amount of feeling has been imported into the discussion, especially amongst our esteemed neighbours across the Channel (who, it is right to add, have done the most effective work), and that is one reason why I refrain from commenting upon the evidence of each investigator.† One circumstance must, however, have struck all who

* 'Proceedings of the Royal Society,' vol. xiii. No. 65: "Experimental Researches on Spontaneous Generation."

† Since the present article was completed, I have read, and recommend for perusal, an able review of the Pouchet-Pasteur controversy, which appeared in the July number (1864) of the 'Medico-Chirurgical Review' ("Recent Researches on the Production of Infusoria").

Although the writer leans to the doctrine of heterogenesis, he has given a very impartial account of the controversy, and has narrated many detailed experiments which my limited space has compelled me to pass unnoticed.

There are, however, two points which it appears to me that the writer has not well considered in his essay. In the first place, he speaks of the formation of "spontaneous eggs," *the production of which has been observed* by Dr. Pouchet, and says that "this observation has not been controverted by the opponents of spontaneous generation;" and, secondly, he believes that the work and opinions of Dr. Pouchet, the champion of "heterogenesis," deserve more consideration than they have received here and abroad.

As regards the first, I would remind him that in another portion of his essay (p. 105) he tells us that the germs in dispute are incapable of being brought to the test of our senses; how their formation can have been observed is therefore somewhat mysterious. And this leads to the inquiry whether Pouchet's published observations have been such as to inspire confidence in their trustworthiness: I fear not. This is not the first controversy concerning the nature of the infusoria in which Dr. Pouchet has taken a prominent part; for when, some sixteen years since, the discussion between the veteran microscopist Ehrenberg and Dujardin was at its height, as to whether the so-called *polygastrica* possessed a series of distinct stomachs connected together by an intestine (as affirmed by Ehrenberg), or whether, according to Dujardin, these so-called stomachs were only "vesicles" or "vacuoles" temporarily formed in the protoplasm, and completely disconnected from one another, Dr. Pouchet stepped in between them, and with as much gravity as he now manifests in the controversy on "spontaneous generation," proceeded to decide the debate. The great have interested themselves in the controversy, and that is, the paucity of information afforded on both sides of the debate, as to the exact nature of the forms discovered in the infusions; for, generally speaking, we hear only of vibriones, monads, bacteriums, terms (if I may venture to say so) which have no accurate scientific meaning, and which represent only moving specks of the most obscure character.

This circumstance is to be explained by the fact that the most striking experiments have been performed by persons almost entirely unacquainted with micro-zoology, or who hold exploded views on many matters connected with that branch of science.

In entering upon a brief description of my personal experiences in connection with this subject, I fear that my labours will not have been lightened by the last criticism; but however small may be the value of the evidence which will be adduced in aid of the solution of this problem, my readers may rest assured that there has been no want of care in the identification of the forms described. Again and again evidence has been rejected by me as insufficient, because the living forms under examination would not admit of accurate description, and the few isolated data which follow have been selected from a mass of notes and sketches, many of which might have been added, were it not for the imperfection of their details.

It is eight or nine years since my attention was first directed to the subject under consideration, and from that time to the present I have, year by year, conducted experiments with a view to test the validity of the doctrine of "spontaneous generation."

The conflicting evidence which was from time to time published by trustworthy and eminent investigators, and the great difficulties that had to be encountered in the shape of adverse weather, the frequent necessity to leave my work unfinished, &c., prevented me until recently from stating what had been the results of my observations; and it has only been within the last few weeks that they have been of a sufficiently positive character to justify my coming to a definite conclusion on the subject of heterogenesis, in the present signification of the term.

defect had been, according to his views, that the disputants had not observed with sufficient accuracy; and he proceeded to state, as the result of his careful investigations, that the *polygastrica* have many *boná-fide* stomachs; that the number and diameter of these stomachs is fixed in each fully-developed species; that they never coalesce, for it is easily perceptible that they have distinct membranes ("des parois distinctes"), and that the pretended rotation of these stomachs is an optical illusion! (Séance de l'Académie, 13 novembre, 1848: 'Comptes Rendus,' xxvii. p. 516.)

It is hardly necessary to state that nearly all these observations have since proved incorrect; and as the learned French anatomist has never acknowledged his mistakes, one of two conclusions is therefore inevitable, *viz.* that he either still unconsciously holds antiquated and inaccurate views, or that when once he has made his declaration on a biological subject, there is no great probability of his afterwards bestowing upon it an unprejudiced consideration.

As to the recent "commission" appointed by the Academy of Sciences to decide between Pouchet and Pasteur, and which ended in the premature (and it appears to me justifiable) withdrawal of Dr. Pouchet, the whole affair had too little of the air of seriousness about it to warrant its being considered in this place.

My first definite evidence was obtained about three years since, when a series of investigations were undertaken by me in conjunction with Dr. Balbiani, of Paris, to whom I have already had occasion to refer as the author of a valuable little work on the sexual phenomena of the infusoria; and it now affords me great pleasure to state that not only did he at that time render me very useful assistance, but he gave me one or two hints which led indirectly to my subsequent experiments. In July, 1862, I forwarded to Dr. Balbiani boluses of various organic substances of which I retained the counterparts, consisting of the green juice of cabbage (chlorophyll), and the juice of fresh and baked meat, variously prepared with gum-arabic, &c.; and although my zoological readers will find that it would be quite immaterial, in the form in which my experiments were conducted, whether or not the atmosphere was excluded from these substances, still I may mention, in passing, that such precautions were taken as to render it very improbable that the air should reach them until they were exposed dissolved in distilled water.

These infusions were examined by my colleague and myself, the results noted, and the contained forms delineated; but Dr. Balbiani's investigations were, in the first instance, more successful than mine, as he was favoured with a more elevated temperature.

Since then I have from time to time exposed to the action of the atmosphere the purest distilled water that I could obtain, with a view to compare the living forms, if any should be present, with those described and delineated by my coadjutor, and with any that I might observe in infusions that have been simultaneously exposed.

Let us see what has been the result:—

Amongst the illustrations first received from Dr. Balbiani was the accompanying, which represents what he called "*Cercomonas fusiformis*," found by him in great numbers in both the *animal* and *vegetable* infusions.

FIG. 1.—Cercomonas fusiformis.
(From Dr. Balbiani's original drawing.)

He designated these little forms after Dujardin, who thus figures one in his work on the Infusoria.*

Dr. Balbiani might with equal propriety have called his animalcule, *Cercomonas acuminata*, also figured in Dujardin's work, from which it differed but slightly, being, I think, the same type.

FIG. 2.—C. fusiformis.—*Duj.*
D'une infusion de mousse, grossi 500 fois."†

* 'Histoire des Zoophytes infusoires.' Paris, 1841.

† Let me draw the attention of my readers to the fact that, according to the theory of "spontaneous generation," this form must have been *produced* by the three totally different substances in which they were found by Balbiani and Dujardin.

In September of the same year, I found this same form in some distilled water into which I had washed a little of the dust from my study window, and was induced in consequence to examine successively dust taken from the high road near my house, which I sprinkled upon distilled water, and *pure boiled distilled water only*, exposed in a clean white saucer to the atmosphere. At the furthest, within a week, I found (along with others) this little type, its presence in the saucer of pure distilled water being accompanied by a slight deposit of dust.

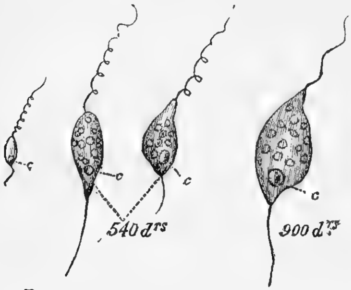
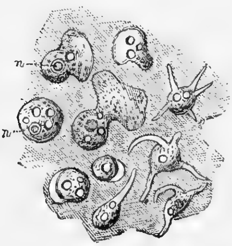


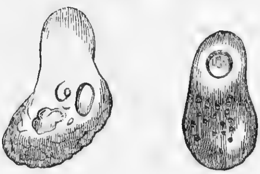
Fig. 3.—Different stages in the growth of *Cercomonas fusiformis*, or *acuminata*, found by the author in pure distilled water. (C. contractile vesicles.)

I followed it in its development from the minutest monad, and was satisfied at length, from the rhythmical movements of its "contractile vesicle," that it was entitled to be called a living infusorium. Since that time I have repeatedly met with it both in pure distilled water and in infusions; and as recently as last June, I found it in sufficient numbers in pure distilled water to enable me to include it in the illustration from nature which accompanies this paper (p. 613).



Another form, *Amœba Gleichenii*, belonging (as the protozoa are now classed) to a still lower group, was observed by Dr. Balbiani in the same infusions with the above-named type, and the accompanying is also engraved from his original drawing of it.

Fig. 4.—"*Amœba* (*Gleichenii?*)"—(n. nucleus.) From Dr. Balbiani's infusions.



I presume that my coadjutor gave it this designation, because the form having the nearest resemblance to it is thus figured by Dujardin.

Fig. 5.—Dujardin's Amœba Gleichenii.

If it were fair to criticize the scientific appellations bestowed upon these minute particles of organized protoplasm, I should say Dr. Balbiani would have done better to give a new specific title to *this* Amœba, for it is widely dissimilar from Dujardin's; but, be this as it may, I have frequently met with similar types in infusions, and last June* *the same* (which I venture to call Balbiani's) appeared in such

* It is right to state that the cause of my success during that month was the high temperature, accompanied by a favourable wind for the conveyance of dust into my vessels of distilled water.

numbers in pure distilled water, that I had ample opportunities to verify and sketch it under the microscope.

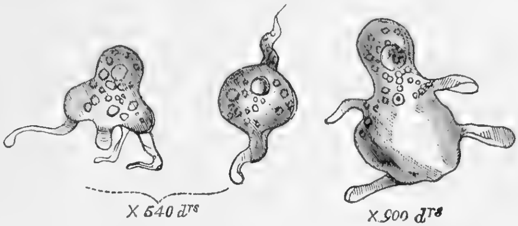


FIG. 6.—*Amœba Balbianii*, found by me in pure distilled water.

My figures are more highly magnified than Dr. Balbiani's; but an inspection of the Plate, and a comparison with my colleague's figures, will exhibit the identity.

Lastly, Dr. Balbiani found in his infusions, both animal and vegetable, a little ciliated type, *Cyclidium glaucoma*, and wrote to me some time afterwards that he had found the same form in moistened dust wiped from his window. He sent me a drawing, which it is, however, unnecessary to append. Here, then, we have characteristic types representing three distinct groups of *Protozoa* which have been observed at the same time in infusions of various kinds, and then the identical types subsequently traced to the atmosphere itself, or to the dust which it holds in suspension.

But the objection, refined as it may be, might not improbably be raised by the advocates of heterogenesis against these experiments, that perhaps the infusoria which I have thus traced in pure distilled water are spontaneously produced from the particles of organic substances which find their way along with dust into the vessel containing the water.

It is, therefore, advisable to meet this difficulty beforehand, and I can best do so by repeating here an account of one of my experiments, described last year before the members of the British Association.* I had exposed (July, 1863,) some pure distilled water in a glass vessel, placed in a box covered with a glass lid, which was left partially open, and after a few days could trace scarcely any appearance of life in the water, inasmuch as the glass cover had intercepted the dust to such a degree as to have become to some extent opaque through the deposit. I therefore removed the dust from the glass lid into the contained vessel, by washing it with a little distilled water, and then left it fully exposed to the atmosphere.

The very next day I re-examined the vessel of distilled water. When exposed on the previous day, the dust had clouded it a little, but now it had settled at the bottom as a fine film or deposit. On pouring off the water carefully, and examining this deposit as it lay in the vessel with a low power (about 75 diameters), it appeared to consist of a number of minute siliceous fragments, interspersed with

* Sub-Section D. "Life in the Atmosphere."

organic particles, both of which seemed to float in a gelatinous film somewhat resembling balsam. Several small cysts, coloured green, were also visible. On adjusting a higher power (200 diameters*), and covering a portion of the thin glass, this gelatinous film proved to consist entirely of transparent colourless "monads," possessing no locomotion, but exhibiting a slight tremulous movement.

I carefully poured back the water into the vessel, and left it until the day following, when, on examining the water, I found it to swarm with "monads." Even those under the covering glass, which I had left undisturbed the day previous, were locomotive and very active. In their forms and movements they resembled various kinds of infusoria, some moving forward with a rapid rotatory motion; others swinging to and fro, progressing more slowly; and others again reminding the observer, by their movements, of the loricated infusoria. Some were globular; others, ovate; and others again, flattened discs. Many were undergoing longitudinal subdivision, and the largest were about 1-700th of an inch in diameter. Transparent vegetable fibres were also present, and these were covered with sessile "monads;" some cysts appeared to have discharged their contents, and were floating empty in the water. At this period, my investigations and experiments, which had been long protracted, were brought to a close.

Was it possible, I would ask, that these swarms of living organisms (to whatever groups they may have appertained) could have been spontaneously produced in a single day from the particles of organic matter which, along with the mineral molecules, were imbedded, as it were, in their aggregated mass? Or is it not more likely that the deposit of dust contained, besides vegetable and mineral particles, a vast number of zoospores, requiring but warmth and moisture to call them into active life? Which is the most rational and scientific method of accounting for their appearance, whether our judgment be based upon theory or experiment?

Let me now add a few of the general results of my prolonged investigations to the special cases already named.

In the course of my experiments with distilled water, I have carefully and repeatedly examined,—1st, dust taken from window-panes, and from other common-place localities at home; in this I have found the following forms, of which I have retained more or less accurate sketches made at the time of observation:—

"*Cercomonas fusiformis;*" various *Amœbæ* (some of them undescribed, as far as I can ascertain), one or two *Vorticellæ*, *Enchelis*, *Kerona* (?), cysts, from which swarms of minute zoospores issued on their being broken by pressure, and in one case I found, in pure water containing nothing but the usual slight deposit occasioned by exposure to the air, what appeared to be the larval form of one of the *Entomostraca*, of which I have no doubt an ovum had found its way into my distilled water.

* I give the measurements in diameters in all cases, chiefly because my instrument is by Schieck, of Berlin, and the English measurements by $\frac{1}{4}$ths, $\frac{1}{8}$ths, &c., are unknown to the foreign makers.

I have also seen plant-cells in great number and variety, and on one occasion the contents of my vessel were, after a few days, tinged green with *Protococcus pluvialis*, as much as if they had been taken from a rain-water cistern.

"*Vibrio*," "*Monas*," and the other types of the partisans of heterogenesis, were of daily occurrence.

In all these cases, I have not the slightest doubt that the atmosphere was the medium through which the germs or spores were conveyed into the distilled water, and it was often a matter of surprise to me that such a number and variety of forms should have become even partially developed, where so little nourishment was afforded for their increase. Let me also add that, contrary to what has been stated by the advocates of heterogenesis, I have always found that the more freely the water was exposed to the air, and the warmer the temperature, the more abundant and diversified were the living types, and the more rapid was their development.*

2nd. I have examined dust shaken from samples of various kinds of cotton rags which had been imported from the following localities:† Egypt, Japan, Tunis, Trieste, Melbourne, and Peru, and in all these different kinds I have found well-marked types of protozoa.‡ To a great degree these types differed from those which I had observed in dust at home, being more active, and highly organized.

In one case I succeeded to some extent in tracing the growth of several of those obscure little forms known as "vibrio" to the annulated, ciliated type here delineated, and saw them cast off ring after ring, which then assumed an independent existence, and commenced to subdivide and extend in length.

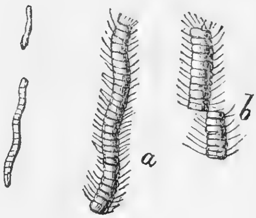


FIG. 7.—Various stages of a Vibrion found in the dust from blue Egyptian rags. *a.* An animalcule 1-150th of an inch in length. *b.* The animalcule casting off several ciliated rings.

As, however, it may be objected, with some show of reason, that the living types from such sources as these afford no *direct* proof of their presence in the atmosphere (although it is well known that the dusty rags imported into this country are for the most part picked up in the streets abroad), I am content to let this evidence go for what it is worth in the eyes of my readers, and mention the matter chiefly as a hint to microscopists where to seek new types of protozoa; but if there be any who are disposed to doubt the presence in the atmosphere of the germs or zoospores of many of those common infusorial types which are supposed by the partisans of "spontaneous generation" to be abnormally produced from the infusions in which they are often met

* I have been the most successful with a shallow white saucer.

† The dust was in all cases carefully sifted through muslin on to the surface of distilled water, and fell to the bottom of the vessel as a fine deposit.

‡ As described in short memoirs read before the Academy of Sciences, Paris, 1863; and Sub-Section D, British Association, 1863.

with, I would recommend them to verify or controvert my statements by the following simple experiment:—

Let them procure some distilled water from a source which is certain to be pure; and to make assurance doubly sure, let it be boiled, or (as Dr. Rolleston, of Oxford, has suggested*) passed slowly through a red-hot platinum tube.

This water should be exposed in an open situation, in a good-sized saucer or soup-plate, and fresh distilled water added day by day, to supply the place of that which evaporates.

The exposure should take place in warm weather, if possible with a light breeze, and not too soon after the air has been purified of its floating contents by a shower of rain.

In a few days, if ordinary success attend the experiment, an inconsiderable sediment of dust will have settled at the bottom of the saucer, and drops of the water, along with a little of this sediment, should be submitted to *careful* microscopic investigation. If I am not greatly mistaken, judging from my own experiments, the most conspicuous types will be found to be those little fragments (more or less definitely shaped) of organized protoplasm known as amœbæ, and the observer will probably notice many interesting phenomena in connection with their growth, permanent changes in form, mode of subdivision, &c., to which my limited space has allowed no reference. When the field is carefully viewed with a high power, there will also probably be found in considerable numbers the little fusiform monads (so frequently referred to in this paper), for in most of my investigations these have first appeared.

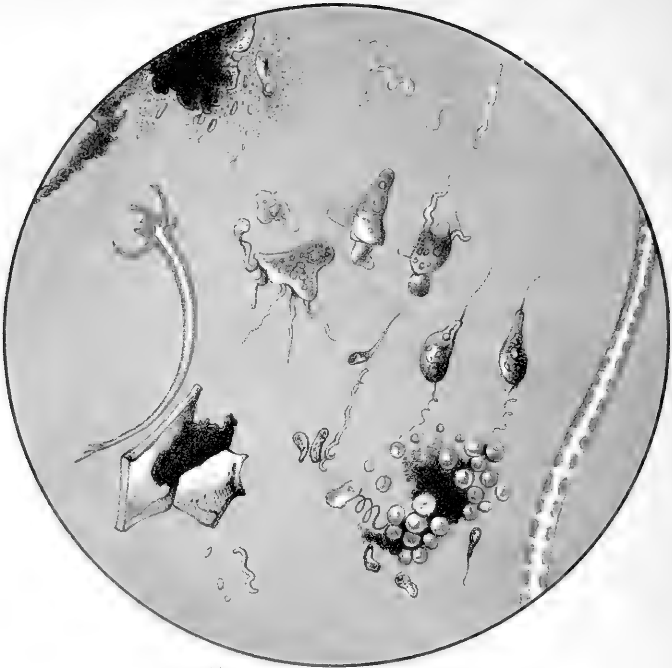
With favourable weather and perseverance, other and probably higher forms will in time become apparent; and I trust that if no other good result from the publication of these imperfect observations, they may lead more careful investigators to favour the microscopical world with valuable contributions to "atmospheric micrography"—contributions of a different kind to the negative ones formerly published under that title by Dr. Pouchet, the zealous champion of heterogenesis.

For the benefit of those, however, whose time or occupations prevent them from investigating for themselves, and who are willing to accredit me with accuracy of observation, I have appended a plate, which will give some idea of the appearance of the microscopical contents of distilled water, after a few days' exposure to the atmosphere in fine weather; but I must state, to avoid misapprehension, that although all the forms and others besides may be contained in the same drop of water, they will probably not appear at one and the same time in the field of the microscope.

The objects represented in Fig. 1 (commencing at the top) are, a fragment of organic matter upon which a swarm of minute zoospores and one or two young ciliated infusoria appear to be regaling themselves; then, between the bright crimson hair (animal or vegetable) and a green plant fibre, probably one of the confervoid

* Sub-Section D, British Association, 1863.

I



II

Edwin M Williams lith.

[illegible] PURE DISTILLED WATER AFTER 14 DAYS
[illegible] DIAMETERS)
[illegible] SOURCE, 900 DIAMETERS

algæ, are seen four amœbæ, and two of the fusiform ciliated "monads" (*Cercomonas fusiformis*); a group of free floating cells, some of which are subdividing, may be observed below; zoospores, or the young of ciliated infusoria, and "vibriones," make up the living contents, whilst a couple of fragments of hard, transparent mineral, probably silex, held together by some softer mineral substance, complete the little group of objects, all of which are magnified 270 diameters.

In Fig. 2 we have one of the larger plant-cells, a little sharp fragment of silex, amœbæ of various types (one very active kind undergoing subdivision), the fusiform "monad," and two young ciliated infusoria, all represented as they appear under a lens magnifying 900 diameters.

But it may be said by the partisans of "spontaneous generation," that the presence of germs in the atmosphere is no absolute disproof of their theory, and they may still maintain that it is possible for inorganic elements or organic compounds so to combine "spontaneously," as to form infinitely minute germs or cells, which are invisible under the highest powers of the microscope.

For the possibility of such a combination, by *artificial* means, they might appeal to the opinion expressed by at least one high biological authority, Professor Huxley, who says (as it was already stated in the Introduction to this Journal), that he believes it possible, before half a century has elapsed, that man may be able to take inorganic substances, such as carbonic acid, ammonia, water, and salines, "and be able to build them up into protein matter," and that that protein matter should "begin to live in an organic form;"* and, for the reasons assigned at the commencement of this paper, it appears to me also that they have the indirect countenance of all thorough believers in progressive development through secondary causes.

Nor would I for a moment venture to deny the *possibility* of such a phenomenon; for, however contrary it may be to analogy and experience, it is impossible to say whether or not the same natural laws operate in the creation of these still invisible forms as in that of the visible organized types.

As Dr. Child has said, some of these forms are no more entitled to be considered independent organisms than white blood-corpuscles, &c.; and I think he might with safety have added, after the publication of Dr. Beale's researches on blood-corpuscles, that some of them are much *less* deserving of the rank of living organisms. It would be presumptuous, then, to deny that such lowly forms may not be created to-day, either artificially or spontaneously.

But that is not the ground hitherto taken by the advocates of "spontaneous generation." They deny the existence of the germs of infusoria in the atmosphere, and would have the scientific world accept their theory as sufficient to account for the presence of all the

* 'Lectures to Working Men.' Professor Huxley is, however, a disbeliever in heterogenesis, and considers that through Pasteur's experiments the doctrine has "received a final *coup de grâce*."

known forms of protozoa (if they do not go still further) which are found in infusions. And upon what biological evidence do they claim a scientific status for their doctrine?

Mainly on the ground, as already observed, that when they have sought to exclude the air from infusions (no doubt as conscientiously as possible), there have, after a certain time, appeared in them "monads," "bacteriums," and "vibriones;" these objects being, generally speaking, and notwithstanding their high-sounding appellation, minute moving *specks*, or lines, even under highest microscopical powers, and concerning which the least scientific reader knows just as much as the most learned investigator.

In this, the popular sense of the term "spontaneous generation," I am certainly no believer; and I have little doubt that the time is not far distant when all those lowly types, now known as protozoa, will be traced in their earliest stages to the atmosphere, the dust of the road, of our parlour windows, and indeed in every place into which dust and air penetrate.

It is the common-sense explanation of their presence; for what is more natural than that, along with the dust, which is dried mud, the wind should also waft about the light zoospores of those minute forms of which the stagnant pool is the habitat? And it is the solution strictly in accordance with scientific experience, for, without reference to the great homogenetic law traceable through the whole organic realm, we have the indubitable fact, that the more lowly the organisms, the more widely are their reproductive principles diffused in the elements.

ON THE FORMATION OF CORAL (*Corallium rubrum*).

By Professor H. Lacaze Duthiers (École Normale supérieure, Paris).

Coral has been in request from the earliest times for the purpose of personal adornment, while its form and properties, which denote at one and the same time the plant and the stone, so masking its real origin, have excited the curiosity alike of the fashionable wearer and of the devotee of science. Its true nature has, however, only been recognized within the last hundred or hundred and fifty years. This has been, in a great measure, due to the absolute impossibility of arriving at any accurate conclusion on the subject without close observation of the animal while living, and to the great difficulty of meeting with it in this condition. As soon as it is removed from the water it dies, and even though preserved in fresh and constantly renewed water, with the most scrupulous care, it still too often speedily perishes. To obtain, therefore, the opportunity for close examination, one course only is open to the inquirer; he must be present at the capture of the animal, and proceed at once with his investigations; and let it be observed that this mode is not always either easy or even possible, for most commonly the *popieri*, or boat masters, are but little disposed to receive on board strangers, whose only object they deem to be that of mastering their secrets and profiting by their skill in finding the localities most favourable for obtaining an abundant supply of coral. They cannot understand that anyone would expose himself to the discomforts of their mode of life, merely to satisfy a curiosity which they are not able to comprehend, by poring over a branch of living coral as it is withdrawn from the water.

I had obtained, at Bonifacio, in Corsica, a promise of all that would be necessary for my purpose; the most gracious assent was given to my expressed desires, but when night came the expedition put to sea, and I saw no more of those upon whose aid I had too confidently reckoned. The search for coral, moreover, is not managed on the same plan as other fisheries. The coral-seekers have to look for banks in very different, and often far distant, localities, according as the wind happens to be favourable or otherwise. They therefore carry provisions for some considerable time, and the period of their return to the port from whence they sailed is indefinite to a degree. I encountered one day, in the Gulf of Propriano, on the shores of Corsica, a little fleet of sixty coral boats; a week afterwards not one remained, nor did I again fall in with them. During my stay at Calle all the fishermen sailed in the month of June for the island of Galito and the waters of Bizerta; they did not return until the commencement of August.

It will be no subject of surprise, then, if the naturalist hesitates before he undertakes a voyage which is so uncertain in the time it will occupy, and constantly attended with fatigue and discomfort. These difficulties, to which indeed many others might be added, serve to explain the slow advance of knowledge in this branch of inquiry, for the task of obtaining living coral, now sufficiently arduous, must have been still more so in former years. It should be observed, however, that if the materials can only be obtained with comparative ease by the dredge, the necessary inquiries may be made with far greater facility.

Leaving unnoticed the fables and prejudices of the ancients, and without entering upon an unsuitable historical *résumé*, we may remark that Reaumur and Swammerdam classed coral among stones; that Marsigli, having seen its flowers, regarded it as a plant; while ultimately the discovery of Peyssonnel assigned to it, in 1729, its legitimate position in the animal kingdom. Reaumur, a singularly truthful and clear-sighted observer, thoroughly recognized the great importance of direct observations, and succeeded in obtaining orders from the Duke of Orleans that messengers should start on foot from Marseilles, to bring to him with all possible care the coral freshly taken on the coasts of Provence. Unfortunately the precious burden had far too feeble a hold of life, and the distance over which it had to pass was much too great. The coral arrived in Paris, it is true, but quite dead, and its examination elicited no new facts; its only result, indeed, being to confirm Reaumur in his erroneous impressions. It is worthy of special note that the most important discoveries have been made by those observers who, regardless of trouble, fatigue, and dangers, have trusted themselves at sea, and have lived the mode of life of the coral fisher.

No one would, indeed, dream of assigning a higher scientific value to the researches of Marsigli and Peyssonnel than to those of Swammerdam and Reaumur; but on which side do we find truth and accuracy? The first-named naturalists elicited new facts, and saw things of which the latter remained ignorant, from this one cause—that they studied the animal still living, and in its normal conditions, and did not draw their conclusions from the dried-up specimens of natural-history cabinets. Have we not here a striking proof of the advantages to be derived from studying animal forms, not alone among the accumulations of museums, but also under those conditions of existence which are peculiar to them, meeting with them, as it were, in their own homes? In this line of inquiry lies, indeed, the future advancement of the natural sciences.

The discovery of Peyssonnel seemed so incredible to Reaumur, that he would not even publish the name of its author. De Jussieu was not more open to conviction, and it was not until after the publication of Tremblay's memorable investigations in regard to the fresh-water hydra, that attention was directed to the dicta advanced by Peyssonnel. Then Reaumur wished to explain away his opposition, but it would seem that the ardent naturalist and traveller, confident of the accuracy of his researches, and mortified by the opposition of the French *savans*, had forwarded his memoirs to England, where they were examined and published, from 1756 to 1759, in the 'Philosophical Transactions.'

Peyssonnel had merited a widely different reception. An impetuous and courageous enthusiast, a true child of the South, he did not shrink before danger or fatigue during his stay on the coast of Africa, then so hostile to an explorer. On other grounds, too, he had well earned the esteem of his fellow-citizens. In 1720, during the terrible plague which desolated Marseilles, he shut himself up with his father in the hospital of the Holy Ghost, there to attend to the plague-stricken, abandoned by all others.

His admiration for nature induced him to devote a part of his fortune to the founding of a prize to recompense studies in marine natural history. The Academy of Marseilles refused it.

It is painful to see Peyssonnel, full of success in his first endeavours, withdraw himself from the scientific arena when the *savans* rejected his discovery, which undoubtedly was one of the greatest of modern times. He no doubt resented the erroneous judgment upon his labours with the promptitude and warmth of feeling manifested by every man who, being a follower of truth and loving science for herself, feels that he is crushed by the lofty position of those who judge him rather than by the force of the arguments which they have marshalled against him.

He accepted the post of Royal Physician at Guadaloupe, and it would appear that in so doing he exiled himself at the same time from his country and from science. No further communication is extant from him to the Academy. It is probable, however, that after he had withdrawn himself from French scientific circles, he still continued to direct his attention to another country, since he addressed his work to the Royal Society of London; then resigning himself to that loss of heart which injustice invariably induces, he ceased to labour, and never again returned to France. The date of his death even is not accurately known.

Peyssonnel was unfortunate. His devotion to the welfare of his fellow-citizens during the fearful epidemic at Marseilles; his generous and liberal offer for the endowment of a prize; his great discoveries in the highest of the natural sciences, transferring to the animal realms a multitude of hitherto so-called plants; these should have secured for him in his own country such a position as would have kept him faithful to science. France would not then have been compelled to regret her indifference to an extended and prolific subject in science, nor to mourn over her neglect of a man who had done her honour; permitting even the date of a valuable discovery, which belonged to her, to be inscribed in the archives of Great Britain.

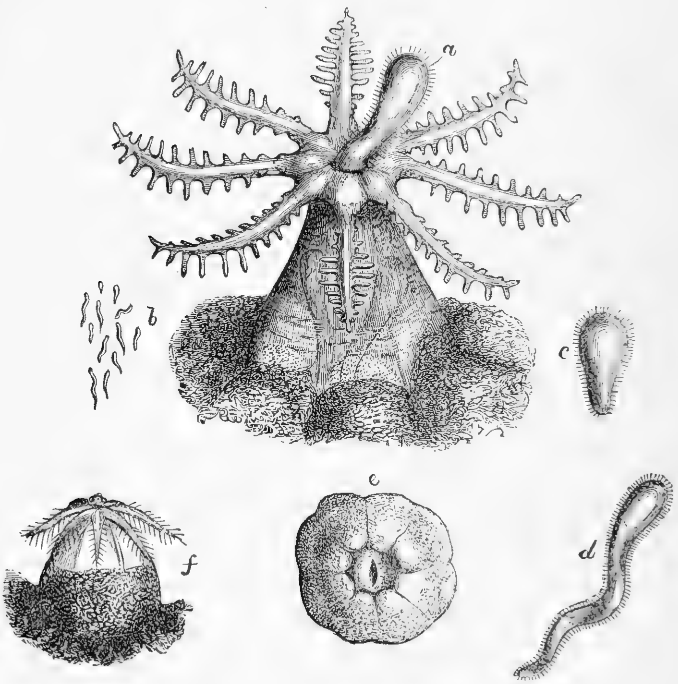
There being no doubt regarding the animal nature of coral, we have now to inquire into its reproduction and development.

If the attempt to keep coral alive should prove successful, and observations be instituted in the fine season, that is, from May to September, at the time when reproduction is proceeding, we shall find that little white ovoid bodies (Fig. 1, *c*) escape from the centre of the graceful rosettes with which the surface of the animal is covered; these in the first instance sink to the bottom of the water, but a short time afterwards acquire an elongated form, and are endowed with the power of movement. These little bodies are not, strictly speaking, ova, since they are already provided with organs of locomotion. They must be considered as embryos, or young polypes.

They possess considerable activity, swim freely, avoid one another in their onward course, and ascend or descend in the glasses in which they are kept. Shortly after their first appearance, or when the water in which they are placed is renewed, their activity is much increased, and they grow considerably in length. They are then completely vermiform (Fig. 1, *b*, *d*).

These leading facts have not been observed without much labour. During the three months of June, July, and August, in spite of every care, and notwithstanding my choice of a very convenient locality, near to Calle, for the carrying out my experiments, the coral submitted to examination died in a most provoking manner. It was in vain that I searched for it myself, and with my own hands collected it with the greatest care from the nets; some hours after my return to the shore it was covered with a thick coating of mould. Judging by analogy with what I had seen among the Gorgonidæ and the true polypes, I took the precaution, towards the middle of August, of going on board one of the coral boats for several days, and then and there to open all the living coral which might be brought up. I hoped to succeed in procuring a premature development of the young polypes, and so to prevent their death; a mode of experiment which had answered my expectations in the case of the Gorgonidæ, Alcyonidæ, and Asterids. I soon collected an enormous quantity of ova, but not one of them survived. I began to despair, attributing these protracted failures to the heat, when at length, in the month of September, after the temperature had somewhat fallen, I obtained an abundance of lively young ones, and was able at once to follow their development.

Fig. 1.



a. Formation of the vermiform larvæ of coral. *b.* Larvæ, or embryos of natural size. *c, d.* The same, magnified. *e.* Disc resulting from the metamorphosis of the worms. *f.* Young polype, with tentacles already provided with processes.

The ova of coral, as we shall soon see, are at first spherical and naked; as they become developed, they increase in length, and are furnished with a well-marked central cavity, communicating with the surrounding fluid by an opening which later on becomes the oral aperture.

When they emerge from the cavity in which they have commenced their transformation, they have acquired a covering of vibratile cilia (Fig. 1, *c*, *d*), and they then completely resemble white worms. They swim with the mouth directed backward, while their larger extremity, or base, looks forward. They have also a tendency to aggregate in clusters, and subsequently incline to adhere to the walls of the glasses, or to objects with which they may come into contact; this tendency is favoured, too, by their mode of progression. Thus, even their activity is a principal cause of their losing the freedom of movement, from its favouring the close adhesion of the posterior part of the body—that part which will ere long be the analogue of the base of the Actiniæ and other adult Zoanthidæ. This proneness to apply themselves to other objects appears specially manifested when the elongated or vermicular form is about to disappear; then the embryos sink down upon themselves, and losing in height what they gain in breadth, change their form into that of small lens-shaped discs (Fig. 1, *e*), in the middle of which the more slender extremity, bearing the mouth, buries itself, and becomes surrounded by a circlet of little cushions. Upon these cushions, and consequently around the mouth, eight small nipple-shaped projections very soon show themselves; these are covered by delicate processes, which subsequently become by elongation the arms of the polype (Fig. 1, *f*). Whilst carefully examining with a lens the stones brought from the bottom of the sea by the nets of the coral fishers, I found little red objects, a quarter and even a half of a millimètre in diameter, which a microscopic investigation showed to be the young bases of coral. Smaller than those which had been formed and fixed in my aquaria, they only as yet enclosed one single animalcule. By further search I was able to follow out all the stages intermediate between the most simple individuals and the most complex branches. Afterwards retracing my steps, I could pursue my inquiries up to the point of the most complete development.

Soon after the young polype has fixed itself, and when its tentacles have become well developed, its white colour disappears, giving place to the characteristic red of coral. (Fig. 1, *f*, represents a young polype of half a millimètre in diameter.) It is difficult to depict the delicacy and elegance of the animal at this stage of its growth. The base or body is of a beautiful rose-colour, while a white coronet formed by the arrangement of the tentacles occupies the upper part. It sometimes presents the illusion of a charming white flower, with its graceful petals surmounting an urn.

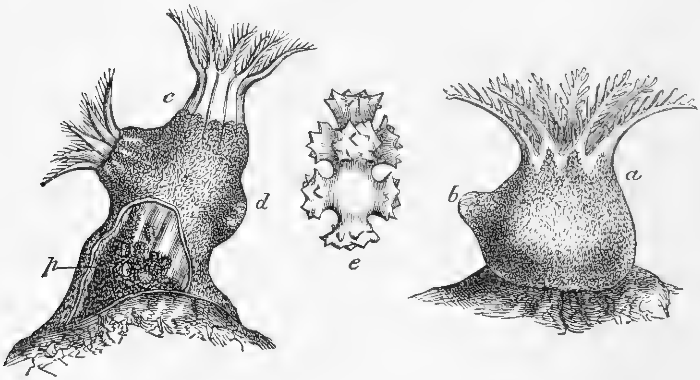
When the first animal, the development of which we have just traced, is complete, a new phase of growth is entered upon. There appear, one by one upon its sides, small nipple-shaped projections, true buds or gemmæ (Fig. 2, *b*, *d*), having their origin in the very tissues of the animal, and provided with a single orifice covered with tentacles; these at length become transformed into so many new polypes, fac-similes of the original animal.

These outgrowths do not separate themselves from the original stock; and since they in their turn become centres from which budding takes place, we may well understand how rapidly the whole number will increase.

This peculiar faculty of increasing by budding is shared by the corallines with vegetables; and to it must be referred the formation of branches and twigs, and the increase in length of the parent stems. But a distinction must be drawn between the multiplication of the number of bases or branches of coral and the increase in number of the polypes. The one is due to the development of ova, the other is accomplished by the repeated appearance of buds.

Before proceeding further, it will be necessary to give some general idea of the plan of organization. Two very different parts may be

Fig. 2.



A young polype, *a*, commencing to throw out buds, *b*; a colony, *c*, which has two polypes and a bud, *d*. At *p* the tissues are laid open, so as to exhibit the first traces of the polypidom in process of formation. *e* is one of the spicules, magnified 900 times, which exist in the crust of coral, and which by agglomeration produce the polypidom.

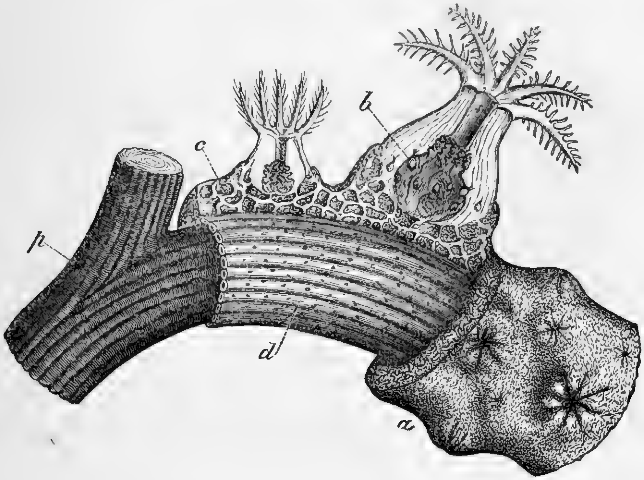
recognized in living coral by the most superficial observation. The one—situated externally and, when recent, perfectly soft; when dried up, friable and easily powdered—constitutes the polyp-bearing or animal layer (Fig. 3, *a*). The incorrect though convenient term which is frequently applied to this part of the animal is "bark." The other, centrally placed, solid and resistant, forms the axis, polyp-stem, or trunk (Fig. 3, *p*). This part only is available for purposes of ornament.

The surface of the cortical portion, when it is well preserved, and especially when quite recent, appears to be covered with minute bosses or little elevations. These bosses are pierced at their apex by a fine perforation with radiating folds, and are hollowed in their interior to form a cavity, from whence the polypes, or "nettles," as Peyssonnel called them, appear to emerge.

Nothing can compare with the graceful arrangement of these little animated flowers; the eight fringed arms with which they are provided are in continual movement; extend themselves in every direction, and then again coil themselves up to convey to the central mouth the prey they have seized. They are milk-white in colour, and stand out in admirable contrast with the lively red of the base. Michelet, therefore, is in error when, in his book on the Sea, he calls them flowers of blood-red tinge.

The tissue of the cortical portion is cellular, soft, and delicate. It is furrowed throughout by vessels, either irregular in pattern (Fig. 3, *c*), or lying side by side and parallel (Fig. 3, *d*), and which put the polypes in direct communication with one another. It encloses also innumerable little calcareous corpuscles (Fig. 2, *e*), red in colour and microscopic in size; these characteristic objects enabling the observer to recognize coral even in its earliest stages. As to the polypes,

FIG. 3.



Part of a branch of coral, magnified and prepared so as to show the polyp-stem, *p*, channelled throughout; to each channel a vessel, *d*, corresponds; *a*, "Bark," permeated by small vessels, *c*, putting the polypes in communication with one another; and a polype, *b*, drawn with ova suspended in the folds of the general cavity.

the walls of their bodies are represented by the bark itself, and their organs exist in the form of slender lamellæ (Fig. 3, *b*), the edges of which, somewhat cushion-shaped and contorted, have a slight resemblance to the convolutions of the intestinal canal.

We have now once more to revert to the question of development, and to inquire how the axis or polyp-stem is formed; the only part, as before said, which is available for personal decoration. The calcareous corpuscles of the cortex are formed soon after the young coral has become fixed or sessile, and on their presence depends the characteristic red colour. In the first instance they are equally disseminated throughout the tissues, but subsequently they multiply and accumulate as nuclei; then a red cement is deposited around them; and these distinct centres, later on, not only unite with one another, but become closely cemented to the submarine bodies upon which the young polype has become fixed. This is the origin of the axis or polyp-stem. It is the same with young polypes as with adult branches; the latter maintaining at their terminal points a perpetual juvenescence, owing to their continued growth. And we find under their cortical covering a partially-formed axis bristling throughout with microscopic asperities representing the corpuscles; these are still recognizable, imperfectly fixed in the cement. At the base of the adult branches the cement is constantly deposited in much greater quantity than towards the extremities, and to this fact the increase in bulk is in great part due. It would appear, too, that the imbedded corpuscles are less numerous at the lower part than at the apex, or in the more recently-formed tissues.

In the interests of general zoology, or the philosophy of the science, the determination of the origin of the axis is of material value, and to this point especial attention should be directed. In some families of the coralline group the polyp-stem is flexible, transparent, and recalls in some measure the horny or epidermic structures among the higher animals. Such are the Gorgonidæ, whose zoological affinities bring them into close relation with coral; and hence, indeed, some authors have been led to believe that the axis of the latter, in spite of its solidity, was constructed by the induration of the epidermis just as we find the polyp-stem to be formed in the Gorgonidæ. It is, however, difficult, after the preceding investigations, to adopt this explanation, since in the interior of the coral axis we find elements similar to those which are disseminated through the deeper parts of the body of the polypes. In this matter a direct application of embryogenic researches has been made available for the purposes of classification.

In conclusion, a few words may be devoted to the phenomena which precede the birth of the embryos, and which have not as yet received notice. Fertilization is accomplished under varying conditions, these having reference to the arrangement of the generative glands, and to the distribution of the individuals of different sexes upon the branches. The polypes, sometimes male, at others female, and lastly, again, hermaphrodite, may be found in close proximity with each other on a single branch, or separate and attached to different branches, where they are clustered together (and this is the most frequent condition), the number of one of the sexes is in excess of the other, very rarely a branch is unisexual, and I have never met with one exclusively composed of hermaphrodite forms. These latter, indeed, are relatively less numerous, and are most commonly scattered irregularly among others, or completely isolated in their very midst. The distribution of the sexes is not, therefore, subject to any special rule. Fertilization, it would seem, then, is sometimes direct, and carried on in a single polype ; at other times indirect, and effected between two individuals on the same, or on distinct branches, always, however, taking place in the general cavity of the body, since it is in this place that the ovum remains and is developed. Further, too, it would seem that the fecundating fluid must be carried to the female polypes by currents of water, as is the case with the mollusks which are of separate sexes, and furnished with adherent shells. The generative glands have no special well-marked form, as in most other animals; their products originating, so to speak, separately, at the base of the intestine-like folds of the general cavity, are contained in capsules which become prominent in proportion to their development, and which are ultimately attached to long pedicles. The ova, after the rupture of the pedicle by which they are suspended, fall into the general cavity and remain there, undergoing transformation up to the moment of the birth of the embryo. The spermatozoa becoming free by the rupture of the capsule which enclosed them are ejected, and fertilize the ova of the females, either directly, if these be near at hand, or by comparative accident if they are not in immediate proximity to the male polype. The emission of the spermatic fluid of the male can be easily detected by direct observation, for it is only necessary to examine some of the living coral at the moment of reproduction, to see the polypes throw out jets of a white liquid, which forms a cloud in the water, and in which, also, the characteristic male elements or the spermatozoa will be discernible.

The ovum, as we have just seen, after detaching itself from the intestiniform folds, falls into the general cavity, where it is fertilized and undergoes its first changes; but in this same cavity another important junction is also accomplished, namely, that of digestion. The same organ therefore serves both as a *stomach* and a *matrix*, or more properly speaking as an ovisac, and in it two substances, under conditions which appear to be similar, can nevertheless undergo modifications thoroughly opposed to each other; for the one is dissolved and liquified, while the other increases in bulk, and produces a new being. This physiological peculiarity cannot fail, from its strangeness, to attract attention; it shows what an immense difference exists between the higher and lower animals, and how difficult it is to judge *à priori* of the one by the other.

As a summary, it may be said that coral follows the ordinary laws of reproduction, and does not present the variations which are met with among some of the inferior animals. For a very short period after its birth it enjoys the power of movement, but as soon as it begins to undergo its metamorphoses the ability to move is lost, and the animal fixes itself in one place, which it does not afterwards desert. Then, too, its early form is lost, and it is no longer possible to recognize in its branches, so elegant in form and so rich in colour, the little white worm from which these were developed. All these facts have, without doubt, a special importance in the history of coral; but they show, also, how the study of the inferior organisms reveals each day some new and unexpected facts; how little the phenomena of life throughout the animal series are as yet understood; and they teach us that such investigations should be conducted with extreme care, and that due reserve and caution should be exercised in reasoning from analogy, and in the application of what we regard as universal laws.

ON THE CONSTRUCTION AND MECHANICAL PROPERTIES OF SUBMARINE TELEGRAPH CABLES.

By William Fairbairn, C.E., LL.D., F.R.S.

Twenty-four years have now elapsed since Professor Wheatstone suggested to the Select Committee of the House of Commons on Railways, the construction of a submarine telegraph between Dover and Calais. Since that time 11,000 miles of cable have been laid, only a little more than one-fourth of which can be said to be in a working conditon; amongst the unsuccessful attempts being the Atlantic cable, measuring 2,200 miles; the Red Sea and India Telegraph, of 3,499 miles, and sundry shorter ones, measuring collectively about 2,300 miles. To account for these misfortunes is a work of some difficulty, owing to the many causes which may affect the integrity of the insulation, or the continuity of the conducting wires. The 8,000 miles of failure have not been, however, wholly lost. They have been the means of accumulating a vast amount of experience, and have suggested remedies for the inevitable difficulties which have to be encountered, now as before, both in the manufacture and in the paying-out of deep-sea cables.

There are two descriptions of cables required for marine construction: one for shallow water, where, owing to the liability of injury from ships' anchors, or the abrasion against rocks or gravel, it is necessary for the insulated wire to be surrounded with an extra strong covering of wire and hemp saturated with pitch; and the other for deep-sea purposes, in which case, as the cable when once laid is supposed to lie perfectly quiescent at the bottom of the ocean, no more strength nor protection is needed than will shield the wire and its insulating coating from injury during the paying-out. Respecting the shallow-water cables, in which category we class the line between Dover and Cape Grinez, laid in 1851; the line from Dover to Ostend, laid in 1853; the one from England and Hanover, 280 miles long, laid in 1858; one between Folkestone and Boulogne, laid in 1859; and one between England and Denmark, 350 miles long, also laid in 1859, all the above are the property of the Submarine Telegraph Company. In addition to these, there are several others which may come into the same class, such as the lines between England and Holland, and the Channel Islands cable, laid between this country and Alderney, Guernsey, and Jersey, in August, 1858.

Amongst the most important of the *deep-sea* cables is that of the Atlantic Telegraph Company. This company obtained an act of incorporation in 1854, which conferred, amongst other privileges, the exclusive right of landing cables on the coast of Newfoundland, or the adjacent islands, for a term of fifty years. The company also obtained a grant of 14,000*l.* per annum from the British Government, and a similar one from the American Government, so long as the line was in working order.

Upon these guarantees and privileges the company was formed, and the cable was manufactured, one half by Messrs. Glass and Elliott, of Greenwich, and the other half by Messrs. Newall and Co., of Newcastle-on-Tyne. As one article has already been devoted to the history of this ill-fated cable,* we will not further allude to it, than to say that the failure of this enterprise may be attributed to the want of care and proper supervision in the manufacture, and, to use the words of the commission, "practical men ought to have known that the cable was defective, and to have been aware of the locality of the defects before it was laid." We might multiply instances of several other similar failures, such as the Red Sea and India, the Spezzia and Corsica, and the Bona and Cagliari cables, all of which are now useless.

In deep-sea lines there are three points which require careful consideration, and which appear essential to success, namely—the tensile strength and conducting power of the cable, perfect insulation, and machinery calculated to pass the cable with safety from the ship into the sea. If this latter can be properly effected, we may venture to assert that a well-insulated cable, when once laid, may be retained for a series of years in satisfactory working order.

In the forthcoming Atlantic telegraph, every possible precaution has been taken to have a sound and suitable cable in the first instance, and Messrs. Glass and Elliott have not only conformed to the recommendations of the scientific committee, but they have chartered the Great Eastern steamship for the exclusive purpose of laying the cable, commencing probably at Newfoundland, and continuing the process of paying-out, as we hope, without break or interruption, till it is safely landed at Valentia. As the construction of the cable is equally important with the skill with which it is laid at the bottom of the Atlantic, it may be interesting to compare the present cable with those previously laid down, and to show with what precaution the directors of the company have undertaken this important and precarious task.

In all the cables we have specified, the same general principles prevail, *viz.*:—

1. The central conductor is a copper wire, or strand of wires.
2. The insulating covering is gutta-percha.
3. The external protection, when used, consists of hemp or other fibrous material, impregnated with pitch or some other resinous substance, nearly in all cases covered with iron or steel, more in the form of an ordinary rope.
4. The cables so prepared have been paid-out over the stern of ordinary vessels, with a pressure-break to regulate the delivery according to the speed of the vessel, which has averaged from four to six knots per hour.

In all cases copper has been chosen for the conducting wire, its durability and its high conducting power rendering it peculiarly applicable for the purpose. In the first telegraphs, the conductor generally consisted of a No. 16 copper wire. This size gave abundant area, and the resistances, even when in lengths of several miles, were

* 'The Atlantic Cable and its Teachings,' QUARTERLY JOURNAL OF SCIENCE, No. 1, p. 44.

not found to interfere seriously with the working. The conducting power of copper wire was taken to be directly as the area ; there were, however, no precise data for determining *à priori* the size of wire requisite for any given length of circuit and speed of transmission. The wire was joined by being carefully lapped and soldered at the joint, and wrapped with smaller binding-wire, which was also soldered with silver solder. In spite of the utmost care in the construction of these joints, some were always imperfect, owing to their liability to fracture, and a break at any single joint destroyed the value of the whole cable. Moreover, the defects in the copper, owing to want of homogeneity, and the presence of foreign matter, frequently rendered the wire so weak that it ultimately parted after being covered, breaking the circuit, or stretched out and reduced the diameter to an inconvenient extent. It was also found that, if the covered wire was excessively stretched, and then allowed to contract, the copper wire, being incapable of regaining its original dimensions, knuckled through the elastic coating.

To remedy these defects, instead of a single copper wire bundles of smaller ones, of similar area, were adopted, the joints being so distributed that the fracture, or defect, of a single wire, does not destroy the whole cable. One serious objection to this form of conductor is that, if a single wire breaks, the sharp end is liable to penetrate through the gutta-percha, and establish a communication with the outer conductor. Such a defect is not easily detected, and it can only be guarded against by close examination of the strand itself, and by the constant testing of the coating during the manufacture. In the form of a strand the bulk of the conductor is also greater, and more gutta-percha will therefore be required to cover it. It will, moreover, not be perfectly solid, but will allow water, if it happen to penetrate to any part of the wire, to pass along as in a tube. This latter objection the Gutta-percha Company propose to remove by coating the central wire of the strand with Chatterton's Compound, and then bedding the six centre wires in it in the process of twisting. The compound squeezed out between the wires unites firmly with the insulating material, and the whole becomes so solid that a few inches of this cable will prevent the percolation of water at a pressure of 600 pounds per square inch. Mr. Daft proposes to obtain the same object by bedding copper wires coated with brass in vulcanized india-rubber. Mr. Clark obtains solidity by making the conductor in the shape of a solid wire, divided into three or four sections longitudinally, fitting closely to each other. Mr. Newall unites the several wires of a strand with solder.

Dr. Matthiesson, Professor Thompson, and other experimentalists, have shown that the quality of the copper exercises a material influence on the conducting power of the wire, and it is very important that copper, as pure as can be obtained in commerce, should be used.

The following table, extracted from the commissioners' report, shows the relative value, or conducting powers, of certain commercial coppers :—

TABLE, *showing the Conducting Power of certain Commercial Coppers.*

Quality of Copper.	Conducting Power.	Temperature Centigrade.	Cause of Diminution of Conducting Power.
Pure copper . . .	100· mean	15·5°	
Specimen furnished by Mr. Tennant, cut from a piece 1½ ton in weight	98·78	15·5	Traces of silver. No suboxide of copper.
American (Lake Superior)	92·57	15·	Traces of iron, silver (·03 per cent.), and suboxide of copper.
Australian (Burra Burra)	88·86	14·	Traces of iron and suboxide of copper.
Best selected . . .	81·35	14·2	Traces of iron, nickel, antimony, suboxide of copper, &c.
Bright copper wire .	72·22	15·7	Traces of lead, iron, nickel, suboxide of copper, &c.
Tough copper . .	71·03	17·3	Traces of lead, iron, nickel, antimony, suboxide of copper, &c.
Russian (Demidoff)	59·34	12·7	Traces of iron, arsenic, nickel, suboxide of copper, &c. The arsenic present may be considered the chief reason of the low conducting power.
Spanish (Rio Tinto).	14·24	14·8	Two per cent. arsenic; traces of lead, iron, nickel, suboxide of copper, &c. The low conducting power is to be attributed to the arsenic present.
Gibraltar core:—			
Specimen, No. 112	90·7	15·5	Traces of lead, suboxide of copper, iron, and antimony.
" " 91	89·5	15·5	
" " 292	78·2	15·5	Traces of lead, arsenic (very small), iron, nickel, antimony, and suboxide of copper.
" " 240	74·4	15·5	

From the above table, it would appear that the difference of conducting power in the different kinds of copper is caused by the impurities contained in the specimens experimented upon. The Rio Tinto copper, in so far as regards its conducting power, being no better than iron.

It has been found that there are no alloys of copper which have a better conducting power than the metal itself; but, as perfectly pure copper is not to be obtained, we have only to reiterate that copper, as pure as can be possibly procured, is the only metal which should be used for the conducting wire of a submarine cable.

Insulation.—As copper seems to stand out prominently as the most fitting conductor, so does caoutchouc, or india-rubber, appear almost specially intended for the purpose of insulation. Its qualities, in this respect, are of the highest order. It is tough, highly elastic, of less specific gravity than water, easily manipulated, extremely durable under water, nearly impervious to moisture, except superficially, and not excessively costly; and on its first introduction it appeared as if nothing further could be desired. One of the first and most important requirements in any insulating substance is that it should offer facilities for making the numerous joints required, either in the first construction of the line or for its repair when laid down. For this purpose, also, india-rubber appeared well adapted : if after being cut the fresh surfaces are immediately brought into contact, almost perfect reunion takes place ; and if they are warmed and slightly moistened with naphtha (in which india-rubber is soluble), they are hermetically sealed. The covering was effected by first coating the copper wire with cotton and shellac varnish, and then winding a thin strip of masticated india-rubber spirally round the wire, each turn overlapping the last. Several coatings were thus put on, the union of the surfaces being secured by means of naphtha. An almost perfect insulation was the first result, the problem on which so much time and money had been expended seemed to be definitely solved, and the new material came into rapid use. A short time, however, showed the fallacy of these hopes. India-rubber, like all other gum-resins of a similar character, slowly burns or oxidizes in the air, even in darkness; but when exposed openly to the weather and to sunlight this oxidization goes on with alarming rapidity; wires hung out of doors soon become useless; the india-rubber assumed a thick gummy or semi-fluid character, and soon fell away from the wire. The joint, even when made with naphtha, was found not to be durable, and after a short time, even in unexposed situations, the coating was found loose upon the wire. Attempts were made to preserve it by enclosing it in grooved boards, and thus protecting it from the air, but in dry situations this was found to be of but little avail; and although in wet tunnels it was found to add to the durability, it was ultimately obliged to be abandoned there also.

Gutta-percha was soon proposed as a remedy for these evils. When pure, and at moderate temperatures, it is a remarkably good insulator, and, moreover, is capable of being kneaded and drawn solidly on the wire through dies, thus avoiding the infinite number of joints required when india-rubber is used. From an analysis by Professor W. A. Miller, it appears that pure gutta-percha is a hydro-carbon, consisting of—

Carbon	88·96
Hydrogen . . .	11·04
	100·00

In commerce, however, it is mixed with resin, vegetable fibre, moisture, &c.; the latter being mechanically diffused through the mass, influencing its pliability and toughness. Commercial gutta-percha will remain unchanged for months in the air, provided light be excluded, and the temperature be not very high ; and it will remain unaltered for years in water, especially if coated with Stockholm tar, and kept in the dark. It is, however, rapidly destroyed by alternated exposure to a moist and dry atmosphere, especially if the sun's rays have access to it. Professor Miller found that all the deteriorated portions had absorbed oxygen.

We have made numerous experiments upon the effect of temperature and hydrostatic pressure on both gutta-percha and caoutchouc. They necessarily occupy a very considerable time, and are otherwise difficult to perform. The general results appear to be that temperature has a very marked effect upon gutta-percha, but that pressure appears to consolidate the material and improve the insulation, of both gutta-percha and india-rubber.

The results may be briefly stated, as follows:—With the gutta-percha in ordinary use for submarine cables, the insulation at 72° Fahr. was not one half as good, and at 92° not one fourth as good, as it was at 52°, and at 52° it was not one third as good as at 32°. Perfectly pure gutta-percha was a far superior insulator, and suffered little loss of insulation, until it attained a temperature of between 72° and 92°. India-rubber and Wray's compound, which are very far superior as insulators to the gutta-percha which has been ordinarily in use, exhibit very little loss of insulating power until they attain temperatures far above 92°.

The experiments at a very high temperature showed that, whilst india-rubber withstood a heat of 200° Fahr., and Wray's compound one of 152°, gutta-percha-covered wire was entirely spoiled at a temperature a little over 122°. At 90° to 100° gutta-percha does not change its shape, but at a higher temperature a wire, when covered with this gum, easily becomes eccentric by the mere process of coiling. Gutta-percha-covered wire should in no case be exposed to heat the exact amount of which cannot be defined and regulated. The material is therefore not a desirable one for cables which have to be conveyed through, or laid in, the tropics, unless means be found for ensuring that the cable be maintained at a low temperature.

When immersed in water gutta-percha, india-rubber, Wray's compound, and Chatterton's compound, absorb a portion. Professor Miller's experiments, in which gutta-percha and india-rubber were subjected to pressure of three tons per square inch for a period of six weeks, show that the absorption of water by gutta-percha is almost *nil* in sea-water, and only trifling, though appreciable, in fresh-water. The absorption of water by caoutchouc is always sensible, the surface being rendered white and opaque. The absorption, however, only reaches to a small depth, and does not destroy, nor in any way impair, the insulating power of the subjacent portion. The white aspect disappears as the substance dries. The amount of absorption is dependent upon the extent of surface exposed to the action of the water. The insulation of specimens of gutta-percha and masticated india-rubber, experimented on by Professor Miller, was in no way impaired by immersion under pressure, but the results with virgin india-rubber were not equally satisfactory.

The experiments conducted by the writer, at Manchester, on the permeability or absorption of water under pressure, and of different degrees of temperature, give variable results, as shown in the following pages. They were instituted to determine the value of the different kinds of insulators under severe pressure, and to ascertain not only the amount of absorption under a force equivalent to the known depths of the Atlantic, but to prove experimentally the properties which peculiarly belong to the material now in use for the purposes of insulation under the varied conditions of pressure, temperature, &c. This being the case, and as these experiments were carried to a much greater extent as regards pressure, we deem it essential to give them *in extenso.*

The following experiments were prosecuted at the request of the Commission, with a view to determine how far the different kinds of material proposed as insulating coverings for electric submarine cables were reliable when placed at the bottom of the ocean under the pressure of superincumbent water. It appears that all insulators which have been subjected to experiment absorb more or less water under pressure, even those that are closest in texture—such as vulcanized india-rubber and gutta-percha; and it seems that this absorption increases the longer the specimen is retained under water, the greater the pressure to which it is subjected, and the higher the temperature of the water in which it is immersed. The very limited time which has been available for these experiments has prevented my doing more than to indicate decisively these general facts, without determining the numerical relations of the quantities absorbed under different conditions of time, pressure, or temperature. But already the experiments point out a very important inquiry, some of the methods by which that inquiry may be prosecuted, and some of the conditions which must be attended to in order to ensure reliable and corresponding results.

Generally, in regard to insulating power, the various materials tried arrange themselves in the following order of permeability, the first absorbing least water, and the last absorbing most:—

1. Chatterton's compound.
2. Gutta-percha.
3. Masticated india-rubber.
4. Vulcanized india-rubber.
5. Carbonized india-rubber.
6. Wray's compound.
7. Unmasticated bottle india-rubber.

The experiments on the insulating power of various cores under pressure are less complete than those on absorption, and have been prosecuted under greater difficulties and with less variety of conditions.

So far as the experiments go, however, Wray's core exhibited very high insulating powers, retaining the charge longer than any other tried. Next in order to this may be placed a core of pure india-rubber coiled in two coats over a wire, but this very rapidly lost its insulating power under pressure. Then, a core of pure gutta-percha cured by the Mackintosh process; and the experiments on this are perhaps the most satisfactory of the series. The pressure was retained upon the cable for 406 hours, in which period it exhibited considerable diminution of insulation. A core of twenty alternate coats of gutta-percha and Chatterton's compound also exhibited good insulation unimpaired after 170 hours' immersion. The experiments on a core subjected to pressure in an insulating liquid before being placed in our hands gave anomalous results. The insulation increased, instead of diminishing, as the liquid dissolved out.

The first experiments have for their object the determination of the increase of weight of various insulating materials, when subjected to enormous pressure under water. A series of insulators were selected, such as gutta-percha, india-rubber, Wray's compound, Chatterton's compound, vulcanized india-rubber, india-rubber compounded with carbon, and marine glue. Of these, suitable-sized pieces were prepared and placed in a strong steel cylinder, and subjected to pressure by means of a lever and plunger. Before their introduction into the cylinder, and whilst dry, they were carefully weighed in a delicate balance. Then, after being subjected to pressure for a shorter or longer period, as the case might be, they were again dried on the surface, and immediately weighed. The increase of weight due to the pressure under water is the measure of the quantity of water which had been absorbed, or rather forced, into the pores of the insulator.

FIG. I.

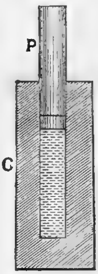


Fig. 1 represents the apparatus employed in these experiments. C is the large cylinder of steel in which the specimens were placed; P, its plunger, 2 inches diameter. Fig. 2 shows the general arrangement of the apparatus; L L, the large lever; F, its fulcrum; and P, the plunger of the cylinder C, in which the weighed specimens were placed. The plunger is guided vertically by the box B B, forming part of the general case or stand in which the lever is placed. By means of weights suspended on the extremity of the lever, the requisite pressure could be applied to the water in the cylinder C.

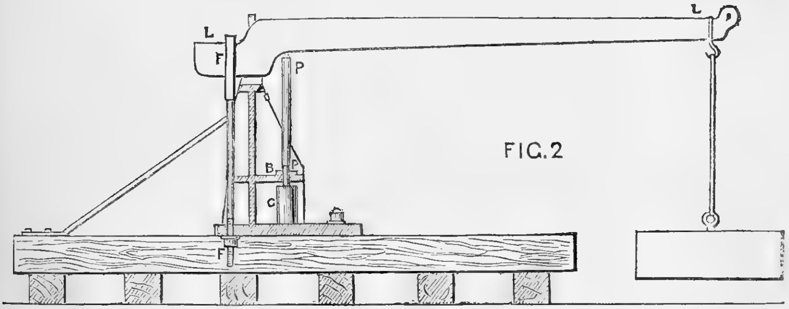


FIG. 2

The temperature in all these experiments was low, sometimes several degrees below the freezing-point. In the first experiment with Wray's compound, the cylinder when opened was found to be filled with loose ice.

In the following table the last column shows the gutta-percha to be least absorbent, and the india-rubber most so. Wray's compound absorbed more than carbonized india-rubber, but less than pure india-

TABLE I.—*First Series of Experiments on Absorption, under a Pressure of* 20,000 *lbs. per square inch, reduced to* 100 *hours' exposure and* 10 *inches area.*

Reduced results.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Area of Specimen, in sq. inches.	Water absorbed, in grains.
1	India-rubber	20,000	8·720	100	10	0·177
2	India-rubber with carbon .	20,000	8·720	100	10	0·055
3	Wray's compound . . .	20,000	8·720	100	10	0·072
4	Gutta-percha	20,000	8·720	100	10	0·044

rubber. The pure india-rubber appears to combine superficially with water as the surface becomes white, either at parts, in the present experiment, or over the whole surface. The carbon appears to prevent the formation of this hydrate, and at the same time reduces the elasticity of the native rubber, and enables it to be worked more kindly.

In the next series, the whole of the specimens were placed in the same cylinder, Fig. 1, and remained under pressure during the same period and under the same conditions.

TABLE II.—*Experiments on Absorption, under a Pressure of* 6,000 *lbs. and at the Ordinary Temperature.*

Results reduced to 10 inches area.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Area of Specimen, in sq. inches.	Water absorbed, in grains.	
1	India-rubber, unmasticated	5,900	2·575	450	10	3·075	
4	India-rubber, masticated .	5,900	2·575	450	10	0·023	
8	,, ,, .	5,900	2·575	450	10	0·636	} 0·682
9	,, ,, .	5,900	2·575	450	10	0·700	
10	,, ,, .	5,900	2·575	450	10	0·711	
11	India-rubber, vulcanized .	5,900	2·575	450	10	0·146	
7	India-rubber, carbonized .	5,900	2·575	450	10	0·980	
2	Gutta-percha	5,900	2·575	450	10	0·378	} 0·307
13	,, ,, ...	5,900	2·575	450	10	0·177	
14	,, ,, ...	5,900	2·575	450	10	0 366	
5	Wray's compound . . .	5,900	2·575	450	10	0·750	} 0·725
13	,, ,, . ; .	5,900	2·575	450	10	0·700	
6	Chatterton's compound .	5,900	2·575	450	10	0·375	} 0·279
12	,, ,, .	5,900	2·575	450	10	0·183	

These tables show that, of all the substances tried, native unmasticated india-rubber absorbs by far the most water. The whole surface of the specimen had lost its black colour, and become whitened during the experiment. Taking the mean of three experiments very closely agreeing, we find that native india-rubber, after manufacture, absorbs less water than in its native state, in the proportion 0·682 to 3·07, or $1 : 4\frac{1}{2}$. Vulcanized india-rubber appears to be the least absorbent substance tried, but when combined with carbon, it absorbs nearly one-third more water (according to the results in this table) than in its pure masticated state. Gutta-percha and Chatterton's compound are nearly alike in their resistance to absorption, the latter being superior. In these experiments they increased in weight only one-half as much as pure india-rubber (masticated), and twice as much as vulcanized india-rubber. Wray's compound absorbed rather more than masticated india-rubber. Marine glue lost instead of increasing its weight.

Comparing these experiments with the last, we find that these materials are far from following a law of simple proportion in the amount of water absorbed in different times. The present experiments were made under a pressure of 5,900 lbs. per square inch, and lasted for a period of 450 hours. The last were made under a pressure of 20,000 lbs., and lasted less than 100 hours. In the present experiments, carbonized india-rubber absorbed seventeen times as much as in the former; Wray's compound, ten times; gutta-percha, seven times; and masticated india-rubber, only four times. Hence it appears that, other things being equal, masticated india-rubber would be most advantageous, and carbonized india-rubber least so, as insulators; because, so far as these experiments afford data for generalizing, masticated india-rubber follows a rate of absorption diminishing most with time, and carbonized india-rubber least so. This deduction, however, is complicated by the fact of a difference of pressure, and possibly of temperature, in the two experiments.

The order of merit in resisting absorption, as derived from this series of experiments, is—

1. Vulcanized india-rubber.
2. Chatterton's compound.
3. Gutta-percha.
4. Masticated india-rubber.
5. Wray's compound.
6. Carbonized india-rubber.
7. India-rubber not masticated.

The next series of experiments was made under greater pressure, but in the same manner and for the same period of immersion.

TABLE III.—*Third Series of Experiments on Absorption, at Ordinary Temperatures.* Reduction of results to 10 inches area.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Area of Specimen, in sq. inches.	Water absorbed, in grains.	
6	Raw india-rubber . . .	15,000	6.54	450	10	1·65	
7	Masticated india-rubber .	15,000	6·54	450	10	0·22	0·26 (7–9)
8	" " .	15,000	6·54	450	10	0·29	
9	" " .	15,000	6·54	450	10	0·30	
10	Carbonized india-rubber .	15,000	6·54	450	10	0·29	
5	Gutta-percha	15,000	6·54	450	10	0·18	
1	Wray's compound . . .	15,000	6·54	450	10	0·56	0·57 (1–2)
2	" " . . .	15,000	6·54	450	10	0·58	
3	Chatterton's compound .	15,000	6·54	450	10	0·054	0·057 (3–4)
4	" " .	15,000	6·54	450	10	0·058	

The temperature during these experiments was generally lower than in the second series, being frequently at the freezing-point. There was loose ice in the cylinder when opened.

The higher pressures in these experiments seem to bring out more decisively the differences in the amount of absorption; but it is remarkable that, whilst the relative absorption does not widely differ, and the order of the insulators in their resistance to absorption is the same, the absolute quantity absorbed under greater pressure is less than in the previous series of experiments. The only discrepancy between the two series of experiments is the relatively low absorption of masticated india-rubber.

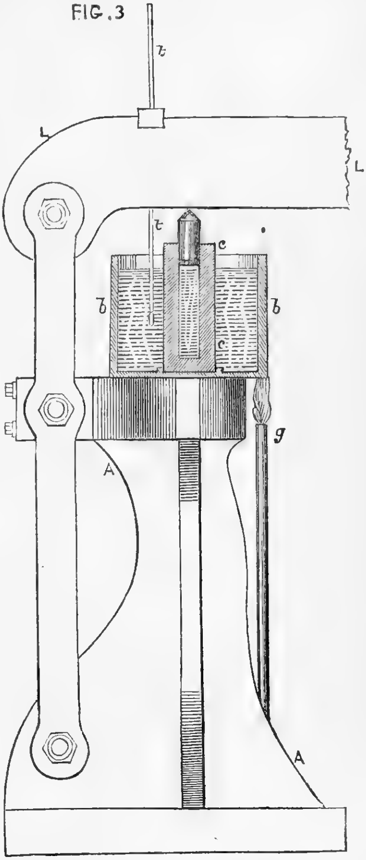
The order of merit, or power of resisting absorption, is in these experiments—

1. Chatterton's compound.
2. Gutta-percha.
3. Masticated india-rubber.
4. Carbonized india-rubber.
5. Wray's compound.
6. Raw india-rubber.

The last in this series absorbed twenty-seven times as much as the first; gutta-percha and Chatterton's compound hold, as before, the highest place, but the superiority of the latter was more manifest; it had become whitened at the surface, but apparently the water had penetrated the thinnest possible film.

The next experiments were made with a view to determine the effect of temperature on the absorption of water by these insulators. Recourse was had to the small cylinder, *c*, Fig. 3, which was surrounded by the water-bath, *b*, *b*, maintained at a uniform temperature of 100° Fahr. by the gas-jet *g*. *t*, *t*, is the thermometer. The lever by which the pressure was applied to the plunger is shown at L, L, attached to the firm cast-iron base, A, A.

FIG. 3



The different substances were tried separately, as in the first series, and the weighings were repeated at intervals. During the night it was necessary to remove the gas jet, as the uniformity of temperature could not be depended upon; hence, for half the period of immersion the specimens were at a temperature of 50° only, and for the remainder at a temperature of 100°. The loss of weight, after removal from the cylinder, in consequence of the evaporation of the water absorbed, was, in these experiments, noted, and it was found the specimens decreased in weight below their original weight when dry.

In the whole of these experiments, the pressure was 20,000 lbs. per square inch; area of specimens, 8 square inches; and thickness, about one-eighth of an inch.

TABLE IV.—*Fourth Series of Experiments on Absorption, at Increased Temperatures.*

Results reduced to 100 hours and 10 inches area.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Duration of Exposure, in hours.	Temperature, Fahr. (Mean).	Area of Specimen, in sq. inches.	Water absorbed, in grains.	Loss of Weight in Drying.
3	Gutta-percha	20,000	100	75°	10	0·27	3·61
4	India-rubber	20,000	100	75	10	0·45	0·87
5	Wray's compound . . .	20,000	100	75	10	0·58	0·91
6	Chatterton's compound .	20,000	100	75	10	0·20	0·60
7	Vulcanized rubber . .	20,000	100	75	10	0·80	2·27

Comparing the numbers in this table with those in the first series, which were made under precisely similar conditions in all respects, except temperature, which then did not exceed an average of 40° or 45° Fahr., it becomes evident that temperature has a considerable effect on the amount of water absorbed. Thus, gutta-percha at 45° absorbed 0·044 grains; at 75°, 0·27 grains, or six times as much. In like manner, india-rubber absorbed 0·177 grains at a lower temperature, and 0·45 at the higher, or two-and-a-half times as much. Wray's compound, 0·072 at the lower temperature, and 0·58 at the higher, or seven times as much.

Reasoning upon the foregoing experiments, a question arises as to the ratio or quantity of water absorbed in different times, and the condition of the specimens after a much more lengthened immersion. The present experiments, although showing the relative permeability of different insulators, do not afford data to determine the ultimate condition of the material intended to surround and insulate the conducting wires of the electric cable. To ascertain these facts, a much more enlarged series of experiments is required, extending over a much greater length of time. If, for example, gutta-percha absorbs ·015 grains of water in 100 hours, under a pressure of 20,000 lbs. on the square inch, we want to determine the corresponding quantity absorbed in 1,000 hours; and further, at what period will the continuous absorption cease? These are questions of vital importance as regards the porosity of the specimens; and, when ascertained, we should still require to know to what extent the insulation of the electric current would be impaired in the cable saturated with moisture.

Should our best insulators, such as Chatterton's compound or gutta-percha, as given in the experiments, arrive at a point at which they will absorb no more water under a given pressure, it then becomes necessary that we should ascertain whether the water imbibed is sufficient to carry off the whole or a part of the voltaic current, and whether the passage of the current through the insulator would accelerate, in turn, the oxidation and consequent destruction of the conductor. To solve these questions, we require, in my opinion, a long series of carefully-conducted experiments, which would tend to give a reliability to these important undertakings which at present they have not attained.

The earlier experiments on the insulating power of various cores when placed under pressure were made with voltaic electricity; but, owing to the shortness of the specimens, it was found impossible to destroy their insulation by the absorption of water so as to permit a current from a small battery to pass through the covering.

Failing in this, recourse was had to frictional electricity, which, from its high intensity, passed with greater or less facility through the insulating coverings of the wire. Still the difficulty of deciding upon the period at which, after remaining under pressure, the insulation began to grow less perfect, remained to a large extent unremoved. This difficulty was very much increased by the necessarily short period in which the experiments had to be completed. It was impossible in many cases to leave the cores long enough under pressure to ascertain clearly the entrance of water; and only in one or two instances was any defect in the cable detected, beyond question, by the gradual loss of insulating power in the specimen under trial. To inadequacy of time were added manipulative difficulties; such as the making of a packed joint which should hold tight against so enormous a pressure as 10,000 lbs. per square inch, and also the variable hygrometric condition of the atmosphere.

The earlier and preliminary experiments were made with a simple double pith ball electrometer suspended from one of the exposed ends of the cable. This method, however, did not allow of sufficient accuracy in the measurement and regulation of the charge and the rate of loss, to afford satisfactory results.

The following method was then adopted. The core was placed in a steel cylinder, E, E (Figs. 4 and 5), with the ends projecting. This

FIG. 4

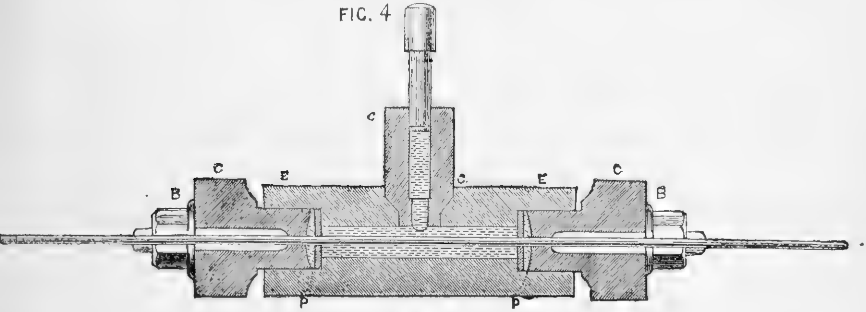
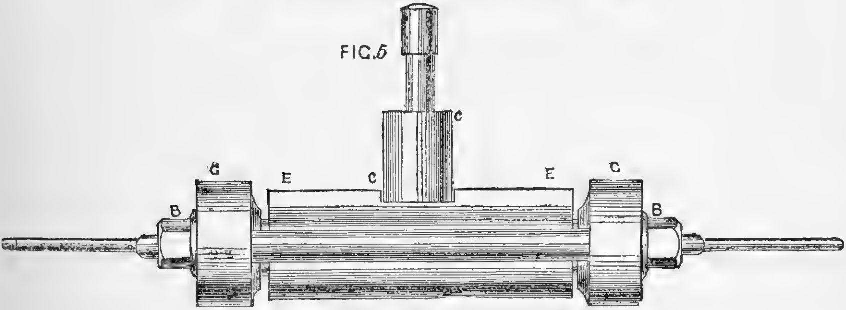
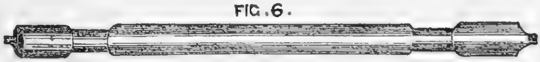


FIG. 5



cylinder was bored out to seven-eighths of an inch diameter, and at either end a pair of strong brass glands, G, G, were fitted, so as to compress round the core the vulcanized india-rubber packing, P, P, by the aid of the bolts and nuts, B, B. The compression thus applied indented the core to a greater or less degree (Fig. 6) at each of the points where

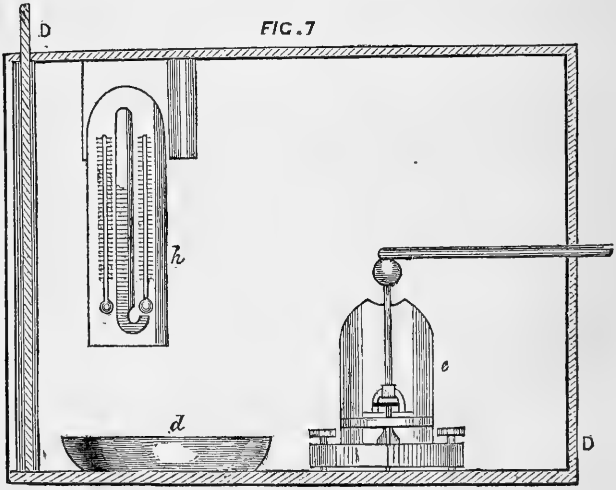
FIG. 6.



the india-rubber packings were applied; and this indentation was greater or less according to the pliability of the insulator. Communicating with the large cylinder, E, E, is a small cylinder, C, C, fitted with a solid plunger. The pressure was applied, through the medium of the plunger, by a lever, L, L (Fig. 3), after the cylinders had been filled with water. Up to about 10,000 lbs. pressure per square inch, or a pressure equivalent to the weight of a column of water 4·36 miles high, the cylinder would stand without leakage; but beyond this pressure the water forced its way amongst the packings, and, either with or without external leakage, prevented the attainment of any higher pressure from the fall of the plunger on its bearings.

One end of the core was hermetically sealed in all but the earliest experiments. The other end was covered with a rounded brass cap, and surrounded by a closed box, D, D (Fig. 7), containing dishes, *d*, of

FIG. 7



concentrated sulphuric acid, an electrometer, *e*, and a hygrometer, *h*. By means of the acid the atmosphere round the cable was kept in a tolerably uniform condition of dryness in a room otherwise damp, and the apparatus and surface of the cable maintained under similar conditions throughout the whole of the experiment.

The electrometer employed is known as the Peltier's electrometer. In this instrument the electricity being simultaneously communicated to a fixed bar and a metallic index, the latter is repelled. A directive force is given to the index by means of a small magnetic needle, in order to retain it at zero when no electric force acts upon it.

The charge was given from an electrophorus, and was ordinarily of such intensity as to deflect the needle through an arc of 70°. The fall of the needle, from loss of charge, was then watched at intervals as nearly uniform as was convenient, until the needle had sunk to 20°.

Although interesting, it would be unnecessary to give the experiments on insulation in detail, and therefore, as in the former experiments on permeability, a summary of results will suffice.

Summary of Results, *showing approximately the Time required in each for a Loss of Charge equivalent to a Fall of the Electrometer Needle of 50°.*

No. of Experiment.	Description of Core.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Time required for Loss of 50°.
I.					
1, 2	Gibraltar core, cured by Mackintosh	10,000	4·363	282	136′.20″
3		10,000	4·363	328	100. 0
4, 5		10,000	4·363	405	32.30
II.					
1, 2, 3	Core impregnated with insulating liquid	0	0	0	6′.20″
4		10,000	4·363	24	11.40
5, 6		10,000	4·363	48	27.35
7		10,000	4·363	56	13. 0
8, 9		13,000	4·363	77	62. 0
10		10,000	4·363	120	97. 0
11, 12, 13		10,000	4·363	170	105. 0
III.					
1, 2	Wray's core	0	0	0	1,300′. 0″
IV.					
2	Wray's core	0	0	0	411′. 0″
V.					
2	Core impregnated with insulating liquid	10,000	4·363	4	68′.30″
3, 4		10,000	4·363	$10\frac{1}{2}$	44.15
VI.					
1	Core of 20 alternate coats of gutta-percha and Chatterton's compound	0	0	0	95′ 30″
2, 3		10,000	4·363	121	42.45
5		10,000	4·363	150	118. 0
6		10,000	4·363	170	100.50
VII.					
1	Core of pure india-rubber	0	0	0	443′. 0″
2		10,000	4·363	80	18. 0
VIII.					
1, 2	Gutta-percha core	0	0	0	4′.30″
3		10,000	4·363	264	8. 0
4, 5, 6		10,000	4·363	480	4. 5
7, 8		10,000	4·363	576	3.37
IX.					
1	India-rubber core	0	0	0	26′. 0″
2		3,977	1·72	390	0. 0
X.					
1	Silver's india-rubber core	0	0	0	380′. 0″
2		0	0	0	387. 0
3		0	0	0	382. 0

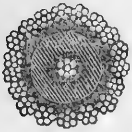
On a careful inspection of the above summary, it will be seen that a great difference exists in the retentive powers of the different insulators under severe pressure: these anomalies almost defy attempts at comparison. If we take No. 1, the Gibraltar core, cured by Mackintosh, we have, after an immersion of 282 hours, at the enormous pressure of 10,000 lbs. per square inch, a power of retention of 136 minutes; at 325 hours' immersion, it is reduced to 100 minutes; and at 405 hours', it is still further reduced to 32 minutes, showing that the insulation is very considerably affected when a sufficiently long period of time is allowed for the permeation of the cable. In the next series of experiments, on a core impregnated with an insulating liquid, we have totally different results, as there is a steady and progressive gain in the insulating powers of the core. At 24 hours of immersion, we have 11 minutes 40 seconds; at 48 hours, 27 minutes 25 seconds; and so on till, at 170 hours, the charge is retained for a period of 105 minutes. Wray's core was too small to be fixed in the cylinder; but it retained a charge under atmospheric pressure for 1,300 minutes, and hence manifested a superiority to all the other cables tried. In another trial with a larger cable, this insulator also gave very satisfactory results. In No. 5 core, of twenty alternate coats of gutta-percha and Chatterton's compound, there are the variable results of an increase in the first five experiments from 43 minutes in 121 hours to 118 minutes in 150 hours; whilst in the sixth experiment, the retention after 170 hours' immersion again falls to 100 minutes. These discrepancies are difficult to account for, and a more lengthened series of experiments is required for the attainment of accurate results. No. 6, a core of pure india-rubber, indicated very good insulation before the pressure was applied; but after 80 hours' immersion the insulation was almost entirely destroyed.

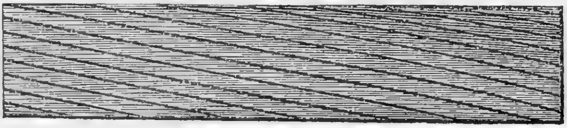
The very important question of insulation in deeply-submerged cables is far from having received, as yet, a complete solution. The foregoing experiments are satisfactory, in so far as they show approximately the relative porosity of various materials; but they do not point out how we are to obtain an insulator impermeable to water, and at the same time a good non-conductor. This desideratum has yet to be attained.

We might have extended our illustrations on the permeability, effects of temperature, and other conditions connected with the insulators now in use; but having already enlarged the article considerably beyond the usual limits, we must conclude with observing, that in the second attempt to ensure success, as regards both the manufacture and laying of the cable, a second series of elaborate experiments had been instituted, under the direction of a scientific committee appointed for that purpose. The results of the experiments are satisfactory and interesting, but we must reserve them for a future notice, at a time when the manufacture is further advanced, and when we may confidently hope that the efforts now making on the part of the directors of the Atlantic cable will be crowned with success.

In the meantime, let us present our readers with drawings and particulars of the two cables, showing that which failed in 1858, and that which is intended for submersion in 1865. From these will be seen the difference of weight and strength, and judging from the precautions that are now taken to have the cable retained in water-tanks, and carefully tested before immersion, we may reasonably infer that, on or before this time next year, a successful and satisfactory telegraphic communication will be permanently established between this country and the American continent.

FIG. 8.—*Cable of* 1858.





Conductor.—A copper strand, consisting of 7 wires (6 laid round 1), and weighing 107 lbs. per nautical mile.

Insulator.—Gutta-percha, laid on in three coverings, and weighing 261 lbs. per knot.

External Protection.—18 strands of charcoal iron wire, each strand composed of 7 wires (6 laid round 1), laid spirally round the core, which latter was previously padded with a serving of hemp saturated with a tar mixture. The separate wires were each $22\frac{1}{2}$ gauge; the strand complete was No. 14 gauge.

Weight in Air.—20 cwt. per nautical mile.

Weight in Water.—13·4 cwt. per nautical mile, or equal to 4·85 times its weight in water per knot; that is to say, it would bear its own weight in a little less than 5 miles depth of water.

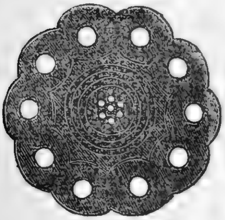
Breaking Strain.—3 tons 5 cwt.

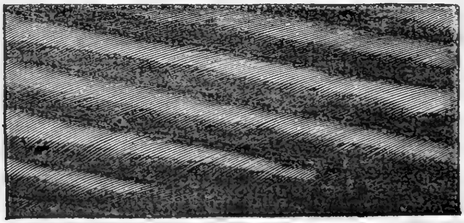
Deepest Water to be Encountered.—2,400 fathoms, or less than $2\frac{1}{2}$ nautical miles in depth.

The Contract Strain was equal to 4·85 times its weight per nautical mile in water.

One Knot, being in fathoms $= 1{,}014 \times 4 = \frac{4917\,0}{2400} = 2{\cdot}05$ times the strength requisite for the deepest water.

FIG. 9.—*Cable of* 1864–5.





Conductor.—Copper strand, consisting of 7 wires (6 laid round 1), and weighing 300 lbs. per nautical mile, embedded for solidity in Chatterton's Compound. Gauge of single wire, ·048 = ordinary 18 gauge. Gauge of strand, ·144 = ordinary No. 10 gauge.

Insulation.—Gutta-percha, four layers of which are laid on alternately with four thin layers of Chatterton's Compound. The weight of the entire insulation, 400 lbs. per nautical mile. Diameter of core, ·464; circumference of core, 1·392.

External Protection.—10 solid wires of the gauge ·095 (No. 13 gauge) drawn from Webster and Horsfall's homogeneous iron, each wire surrounded separately with 5 strands of Manilla yarn, saturated with a preservative compound, and the whole laid spirally around the core, which latter is padded with ordinary hemp, saturated with preservative mixture.

Weight in Air.—35 cwt. 3 qrs. per nautical mile.

Weight in Water.—14 cwt. per nautical mile, or equal to 11 times its weight in water per knot; that is to say, it will bear its own weight in 11 miles depth of water.

Breaking Strain.—7 tons 15 cwt.

Deepest Water to be Encountered.—2,400 fathoms, or less than $2\frac{1}{2}$ nautical miles in depth.

The Contract Strain is equal to 11 times its weight per nautical mile in water.

One Knot, being in fathoms = 1,014 × 11 = $\frac{11154}{2400}$ 4·64 times the strength requisite for the deepest water.

ON THE PROPORTIONAL NUMBERS OF THE ELEMENTS.

By William Odling, M.B., F.R.S.

Upon arranging the atomic weights or proportional numbers of the sixty or so recognized elements in the order of their several magnitudes, we observe a marked continuity in the resulting arithmetical series, the only exceptions to the very gradual increase in value of the consecutive terms being manifested between the numbers 40 and 50, 65 and 75, 96 and 104, 138 and 184, 184 and 195, and 210 and 231·5, thus:—

H	1	Hydrogen.	Fe	56	Iron.	Cd	112	Cadmium.
L	7	Lithium.	Co	59	Cobalt.	Sn	118	Tin.
G	9	Glucinum.	Ni	59	Nickel.	U	120	Uranium.
B	11	Boron.	Cu	63·5	Copper.	Sb	122	Antimony.
C	12	Carbon.	Yt	64	Yttrium.	I	127	Iodine.
N	14	Nitrogen.	Zn	65	Zinc.	Te	129	Tellurium.
O	16	Oxygen.	As	75	Arsenic.	Cs	133	Cæsium.
F	19	Fluorine.	Se	79·5	Selenium.	Ba	137	Barium.
Na	23	Sodium.	Br	80	Bromine.	V	137	Vanadium.
Mg	24	Magnesium.	Rb	85	Rubidium.	Ta	138	Tantalum.
Al	27·5	Aluminium.	Sr	87·5	Strontium.	W	184	Tungsten.
Si	28	Silicon.	Zr	89·5	Zirconium.	Cb	195	Niobium.
P	31	Phosphorus.	Ce	92	Cerium.	Au	196·5	Gold.
S	32	Sulphur.	La	92	Lanthanum.	Pt	197	Platinum.
Cl	35·5	Chlorine.	Dy	96	Dydymium.	Ir	197	Iridium.
K	39	Potassium.	Mo	96	Molybdenum.	Os	199	Osmium.
Ca	40	Calcium.	Ro	104	Rhodium.	Hg	200	Mercury.
Ti	50	Titanium.	Ru	104	Ruthenium.	Tl	203	Thallium.
Cr	52·5	Chromium.	Pd	106·5	Palladium.	Pb	207	Lead.
Mn	55	Manganese,	Ag	108	Silver.	Bi	210	Bismuth.
						Th	231·5	Thorinum.

With what ease this purely arithmetical seriation may be made to accord with a horizontal arrangement of the elements according to their usually received groupings, is shown in the following table, in the first three columns of which the numerical sequence is perfect, while in the other two the irregularities are but very few and trivial:—

			Ro 104	Pt 197
			Ru 104	Ir 197
			Pt 106·5	Os 199
H 1	„	„	Ag 108	Au 196·5
„	„	Zn 65	Cd 112	Hg 200
L 7	„	„	„	Tl 203
G 9	„	„	„	Pb 207
B 11	Al 27·5	„	U 120	„
C 12	Si 28	„	Sn 118	„
N 14	P 31	As 75	Sb 122	Bi 210
O 16	S 32	Se 79·5	Te 129	„
F 19	Cl 35·5	Br 80	I 127	„
Na 23	K 39	Rb 85	Cs 133	„
Mg 24	Ca 40	Sr 87·5	Ba 137	„
	Ti 50	Zr 89·5	Ta 138	Th 231·5
	„	Ce 92	„	
	Cr 52·5	Mo 96	V 137	
	Mn 55		W 184	
	Fe 56			
	Co 59			
	Ni 59			
	Cu 63·5			

If we compare together certain pairs of more or less analogous elements, we find in a considerable number of instances, embracing one-half the entire number of elements, a difference in atomic weight ranging from 84·5 to 97, as shown in the following table:—

I	–	Cl	or	127	–	35·5	= 91·5
Au	–	Ag		296·5	–	108	= 88·5
Ag	–	Na		108	–	23	= 85
Cs	–	K		133	–	39	= 94
Te	–	S		129	–	32	= 97
W	–	Mo		184	–	96	= 88
V	–	Cr		137	–	52·5	= 84·5
Hg	–	Cd		200	–	112	= 88
Cd	–	Mg		112	–	24	= 88
Ba	–	Ca		137	–	40	= 97
Bi	–	Sb		210	–	122	= 88
Sb	–	P		122	–	31	= 91
U	–	Al		120	–	27·5	= 92·5
Pb	–	Sn		207	–	118·5	= 88·5
Sn	–	Si		118·5	–	28	= 90·5
Ta	–	Ti		138	–	50	= 88
Pt	–	Ro		197	–	104	= 93
Os	–	Pd		199	–	106·5	= 92·5

In about one-half of the above instances, the two elements associated with one another, are known to be the first and third terms respectively of certain triplet families; and the discovery of intermediate elements in the case of some or all of the other pairs, is not by any means improbable. Consequent upon the existence of these triplet groups, we have a considerable number of pairs of elements, also including more than one-half the entire number of elements, in which the average difference of atomic weight is about half as great as the average difference between the previously cited pairs, thus:—

I	–	Br	or	127	–	80	= 47	or	48
Br	–	Cl		80	–	35·5	= 44·5		44
Cs	–	Rb		133	–	85	= 48		48
Rb	–	K		85	–	39	= 46		48 ?
Te	–	Se		129	–	80	= 49		48
Se	–	S		80	–	32	= 48		48
W	–	V		184	–	137	= 48		48
V	–	Mo		137	–	96	= 41		40
Mo	–	Cr		96	–	52·5	= 43·5		44
Cd	–	Zn		112	–	65	= 47		48
Zn	–	Mg		65	–	24	= 41		40
Ba	–	Sr		137	–	87·5	= 49·5		48
Sr	–	Ca		87·5	–	40	= 47·5		48
Sb	–	As		122	–	75	= 47		48
As	–	P		75	–	31	= 44		44
Ta	–	Zr		138	–	89·5	= 48·5		48
Zr	–	Ti		89·5	–	50	= 39·5		40

At present there seems no reason to anticipate the existence of an intermediate term between any one of these pairs of elements.

In ten instances we find that more or less analogous elements have a difference in atomic weight of 16, or something approximating closely thereto; and in seven of these instances, the element of lowest atomic weight is the first member, and the element compared therewith the second member of the group to which they both belong, or may be considered to belong, as shown in the following table, which includes nearly one-third of the entire number of elements:—

Cl	–	F	or	35·5	–	19	=	16·5
K	–	Na		39	–	23	=	16
Na	–	L		23	–	7	=	16
Mo	–	Se		96	–	80	=	16
S	–	O		32	–	16	=	16
Ca	–	Mg		40	–	24	=	16
Mg	–	G		24	–	9	=	15
P	–	N		31	–	14	=	17
Al	–	B		27·5	–	11	=	16·5
Si	–	C		28	–	12	=	16

In looking over the above tables, we can scarcely help noticing that those elements whose resemblance to one another is most pronounced, have a difference of about 48 between their respective atomic weights, that is to say, the largest difference in atomic weight known to exist between what are conceived to be proximate elements, as shown in the following table, which also includes nearly one-third of the entire number of elements. For example, the resemblance of cadmium to zinc, where the difference in atomic weight is 47, is greater than the resemblance of zinc to magnesium, where the difference is 41; while the resemblance of antimony to arsenic, where the difference is again 47, is greater than the resemblance of arsenic to phosphorus, where the difference is 44. Moreover, the co-resemblances of cæsium, rubidium, and potassium, and of barium, strontium, and calcium, with a common difference of about 48 between the proximate members, are far closer than the co-resemblances of potassium and sodium, and of calcium and magnesium respectively, with a difference of 16 in each instance:—

”				Zn	65	+	47	Cd	112			”	
”				As	75	+	47	Sb	122			”	
”				Br	80	+	47	I	127			”	
S	32	+	48	Se	80	+	49	Te	129			”	
K	39	+	46	Rb	85	+	48	Cs	133			”	
Ca	40	+	47·5	Sr	87·5	+	49·5	Ba	137			”	
”				Zr	39 5	+	48·5	Ta	138			”	
”				”				V	137	+	48	W	184

If we consider the analogous elements having a difference of about 48 in their respective atomic weights, to stand upon the same level, we may represent those with a difference of 44 or 40 as standing one or two stages above or below the level, as shown in the next table :—

Monads.	Dif. 4	”	Br 80	I 127		
	F 19	Cl 35·5	”	”		
	Dif. 12	”	”	Ag 108		Au 196·5
	L 7	Na 23	”	”		Tl 203
	Dif. 16	K 39	Rb 85	Cs 133		”
Dyads.	O 16	S 32	Se 80	Te 129	”	
	Dif. 8	”	”	V 137	W 184	
	Dif. 8	”	Mo 96	”	”	
	Dif. 4	Cr 52·5	”	”	”	
	Dif. 8	”	Zn 65	Cd 112		Hg 200
	G 9	Mg 24	”	”		Pb 207
	Dif. 16	Ca 40	Sr 87·5	Ba 137		”
Triads.	Dif. 4	”	As 75	Sb 122		Bi 210
	N 14	P 31	”	”		”
	Dif. 4	”	”	U 120		
	B 11	Al 27·5	”	”		
	Dif. 16	”	Ce 92	”		
Tetrads.	Dif. 8	”	”	Sn 118	”	
	C 12	Si 28	”	”	”	
	Dif. 12	”	Zr 89·5	Ta 138	”	”
	Dif. 8	Ti 50	”	”	Cb 195*	Th. 231·5

By a slight modification of the above table, the occupants of similar positions in different groups, having nearly the same

* The analysis of niobic chloride by H. Rose gives 195, while the determination of its vapour density by Deville and Troost gives 173 for the atomic weight of niobium, the mean being 184.

atomic weights, may be brought into association with one another, thus :—

”		”		Ag	108	Au	196·5
”		Zn	65	Cd	112	Hg	200
Na	23	”		”		Tl	203
Mg	24	”		”		Pb	207
”		”		Sn	118	”	
Al	27·5	”		U	120	”	
”		As	75	Sb	122	Bi	210
Si	28	”		”		”	
P	31	”		”		”	
S	32	Se	79·5	Te	129	”	
”		Br	80	I	127	”	
Cl	35·5	”		”		”	
K	39	Rb	85	Cs	133	”	
”		”		V	137	”	
Ca	40	Sr	87·5	Ba	137	”	
”		Zr	89·5	Ta	138	”	
”		Ce	92	”		”	
”		Mo	96	”		”	
Ti	50	”		”		Th	231·5
Cr	52·5	”		”		”	

The parallelism between the monatomic and diatomic alkaline groups, is shown still more strikingly below :—

		Dif. 1.		Dif. 2.		Dif. 4.		Dif. 4.	
		”		*X*	63	Ag	108	Au	196·5
		”		Zn	65	Cd	112	Hg	200
	Dif. 8								
L	7	Na	23	”		”		Tl	203
G	9	Mg	24	”		”		Pb	207
	Dif. 16								
		K	39	Rb	85	Cs	133	”	
		Ca	40	Sr	87·5	Ba	137	”	

Seeing the large number of instances in which the atomic weights of proximate elements differ from one another by 48, or 44, or 40, or 16, we cannot help looking wistfully at the number 4, as embodying somehow or other the unit of a common difference, especially when we find in addition that several pairs of strictly analogous elements differ in atomic weight by this same number, as shown below :—

Fe	–	Cr	or	56	–	52·5	=	3·5
Co	–	Mn	or	59	–	55	=	4
Cu	–	Ni	or	63·5	–	59	=	4·5
Dy	–	Ce	or	96	–	92	=	4

But on the other hand it must be borne in mind that the differences between the several atomic weights compared with one another, are for the most part not exactly but only approximately multiples of 4; whilst in a few instances, at any rate, the approximate difference in atomic weight between closely allied elements, is not 4 or some multiple of 4, but 2 or some odd multiple of 2, and in other instances even 1 or 0.

Since many of the elements occupying analogous positions in different groups have closely approximating atomic weights, it is evident that the mere determination of the atomic weight of a newly-discovered element assists us but very little in deciding to what group it belongs, but only indicates its position in the group; since among the members of every well-defined group the sequence of properties and sequence of atomic weights are strictly parallel to one another.

Doubtless some of the arithmetical relations exemplified in the foregoing tables and remarks are simply accidental; but taken altogether, they are too numerous and decided not to depend upon some hitherto unrecognized general law.

ON THE BUTTERFLIES OF MADAGASCAR.

By Roland Trimen (Cape Town), Memb. Ent. Soc. Lond.

In the belief that a brief consideration of the Rhopalocera inhabiting Madagascar may in some degree aid in the investigation of the relations of the general fauna of the island to that of Africa, which has been so ably commenced by Dr. Sclater,* I have drawn up the following notes. I must at the outset express my regret that the materials at my disposal have been too scanty to admit of the preparation of a paper affording a complete view of the subject under discussion; but it is hoped that these few remarks may prove of service to those who have access to ample means of pursuing the inquiry. I would observe, however, that the data and observations here given are, for the greater part, the results of some years' study of the butterflies of Southern Africa. My obligations to Dr. Boisduval's admirable work, the 'Faune Entomologique de Madagascar, Bourbon et Maurice,'† are too manifest to require comment.

The total number of butterflies known to me as inhabiting Madagascar (exclusive of the Mascarene Islands) is 73. These 73 species are comprised in 34 genera, and belong to the following 11 families, *viz.*:‡—*Papilionidæ, Pieridæ, Danaidæ, Acræidæ, Nymphalidæ, Satyridæ, Eurytelidæ, Libytheidæ, Erycinidæ, Lycænidæ,* and *Hesperidæ.*

* "The Mammals of Madagascar," in 'Quarterly Journal of Science,' No. 2, April, 1864.

† Paris, 1833.

‡ I follow the arrangement of Messrs. Doubleday and Westwood's 'Genera of Diurnal Lepidoptera.'

All these families are represented in Africa. The four families which, it appears, are not represented in Madagascar are also wanting on the African continent, and are these, *viz.*:—The *Ageronidæ*, *Heliconidæ*, and *Brassolidæ*, which are confined to the New World; and the *Morphidæ*, which, though chiefly American, are represented in Asia by several species.

It will, perhaps, more clearly exhibit the close connection between the continental and insular Rhopalocera if, at the risk of wearying the reader with details, the genera and species of each Madagascarian family are briefly considered in regular order.

The PAPILIONIDÆ, a family which, though poor in generic forms, is numerous in species and of world-wide distribution, are represented by six species of the genus *Papilio*, if we include the doubtfully distinct *P. Epiphorbas*, which Boisduval himself considers "pourroit bien n'être qu'une modification locale" of the Mauritian *P. Phorbanta*, Linn.,* and if *P. Nireus*, Linn., be truly a native. The last-named species, *P. Merope*, Cram., and *P. Demoleus*, Linn., range over the greater part of Africa, extending to Sierra Leone; *Lalandei*, Godt., inhabits South Africa; and the splendid *Antenor*, Drury, taken by Mr. E. L. Layard, on the north-west coast of Madagascar, is recorded by both Boisduval† and Westwood‡ as a native of tropical Africa, a specimen in the Hopeian Collection having been received from Timbuctoo.

The PIERIDÆ include the four genera *Pontia*, *Pieris*, *Anthocharis*, and *Terias*, comprising in all nine species: *Pontia syvicola*, Bd. (= *Narica*, Fab. = *Alcesta*, Cram.), ranges to Senegal. Of the genus *Pieris*, one species, *Helcida*, Bd.,—if not a variety of the African *Chloris*, Fab.,—is endemic; *Phileris*, Bd., is found in Southern and Eastern Africa; *Orbona* and *Malatha*, Bd. (= *Saba*, Fab.), in Eastern and Western Africa; while the abundant *Mesentina* extends from Damara Land to Bengal. *Anthocharis Evanthe*, Bd., is among the species taken in Madagascar by Mr. Layard; and a specimen in the British Museum purports to be from "South Africa," but this *habitat* seems doubtful. The three species of *Terias* are all African; but while *Floricola*, Bd. (= *Hecabe*, Linn.), ranges to Java and Northern India, and *Pulchella*, Bd. (= *Rahel*, Fab.), is found at Sierra Leone, *Desjardinsii*, Bd., does not appear to spread farther than the Eastern and Southern coasts of Africa.

But one of the recorded three genera and four species of the family DANAIDÆ is found in Africa, and that one, *Danais Chrysippus*, Linn., is everywhere abundant, and is also common in Southern Asia. *Hestia Lyncea*, Drury, inhabits the Eastern Archipelago; but *Euplœa Phædone* and *Euphone*, Fab., appear to be limited in range to Madagascar and Mauritius.

The slow-flying, inert, but abundant butterflies forming the family ACRŒIDÆ are pre-eminently African, though a few representatives of

* 'Faune Ent. de Mad., &c.,' p. 13. *Epiphorbas* and *Phorbanta* are almost certainly but insular varieties of the widely-ranging and abundant *P. Nireus*, which Boisduval (*op. cit.*, p. 16) considers a doubtful native of Madagascar.

† 'Species Général des Lep.,' p. 190.

‡ 'Arcana Entomologica,' vol. i., p. 146.

the group are American, two species Asiatic, and one Australian. As many as ten species of *Acrœa* (the only genus in the family) have been taken in Madagascar, and of these no less than six appear peculiar to the island. The four found in Africa are *Sganzini*, Bd. (= *Lycia*, Fab.), and *Manjaca* Bd. (= *Serena*, Fab.), extending to Sierra Leone, and the South African *Rahira*, Bd., and *Punctatissima*, Bd.

Ten genera of the Nymphalidæ are represented, *viz.*:—*Atella* (1 species), *Pyrameis* (1), *Junonia* (5), *Myscelia* (1), *Cyrestis* (1), *Neptis* (3), *Diadema* (2), *Godartia* (1), *Aterica* (1), *Nymphalis* (1). *Atella Phalanta*, Dru., inhabits a wide region, from Sierra Leone to Northern India and Java. The world-wide distribution of *Pyrameis Cardui*, Linn., is well known. Two species of *Junonia* seem endemic, *viz.*—*Gondotii* and *Andremiaja*, Bd.; *J. Augustina*, Bd., occurs in Mauritius and Bourbon; *Rhadama* is found in Mozambique;* and *Epiclelia*, Bd. (= var. *Clelia*, Cram.), is a widely-spread African. *Myscelia Madagascariensis*, Bd., is peculiar to the island. *Cyrestis elegans*, Bd., must also be classed among the endemic insects, unless the species stated by Chenu† to inhabit Sierra Leone should prove to be identical with it. *Neptis Kikideli*, Bd., does not appear to have been met with out of Madagascar, but *N. Frobenia*, Fab., extends to Mauritius; and *Saclava*, Bd., is found both in Mozambique‡ and in the Cape Colony. Of the two *Diademæ*, *Bolina*, Linn., has an extraordinary range, only second to that of *P. Cardui;* while *Dubia*, Palis. de Beauv.,§ is recorded from both Eastern and Western Africa. The genus *Godartia* is represented in Eastern and Western Africa,‖ but *G. Madagascariensis*, Lucas, does not seem to extend beyond the island. *Aterica Rabena*, Bd., is likewise an endemic species. *Nymphalis Candiope*, Godt., taken by Mr. Layard on the north-west coast of Madagascar, inhabits the country west of Lake Ngami, from whence a specimen was brought me by Mr. John A. Bell.

The Satyridæ would appear to be but poorly represented in the island, only four species, belonging to the genera *Cyllo*, *Erebia*, and *Mycalesis*, being recorded in the 'Faune Entomologique,' &c. *Cyllo Leda*, Linn., almost rivals *Diadema Bolina* in its area of distribution; but *C. Betsimena*, Bd. (if not, as I am inclined to think, identical with *Gnophodis Parmeno*, E. Doubl.), is confined to Madagascar. *Erebia Tamatavæ*, Bd., is endemic. *Mycalesis Narcissus*, Fab., extends to the Mascarene Islands as well as to South-eastern Africa.

Two butterflies of the small family Eurytelidæ have been discovered in Madagascar, *viz.*:—*Eurytela Dryope*, Cram., and *Hypanis Anvatara*, Bd. (= var. *Ilithyia*, Dru.). Both of these are widely-spread Africans, and the latter species also ranges to Southern Asia.

The curious Libytheidæ are represented by the very distinct *Libythea fulgurata*, Bd., which seems more nearly related to the Javanese

* See Hopffer in Peters' 'Reise nach Mossambique.—Ins.,' p. 380.

† 'Encyc. d'Hist. Nat.—Pap.,' p. 125.

‡ Hopffer's *Neptis Marpessa* is indubitably the same insect.

§ Probably the same as *D. Anthedon*, E. Doubl. ('Gen. Diurn. Lep.'), which inhabits Western Africa and Natal.

‖ See Chenu, *op. cit.*, p. 137; and Hpfr.—Peters' 'Reise, &c.,' p. 386.

L. Narina, Godt., than to any other species. As the genus is found on the African continent,* it is not improbable that *Fulgurata* will be discovered there.

One example of the ERYCINIDÆ—a family abundantly developed in South America—has been found in the island, *viz.—Emesis Tepahi*, Bd. This insect seems more strictly referable to the genus *Taxila*, E. Doubl., which comprises several Oriental, and one, if not two, African species,—*T. Tantalus*, Bd., being a native of Ashanti,† and *Baucis*, Dru. (mentioned by Boisduval as congeneric with *Tepahi*) being recorded by Drury as inhabiting Sierra Leone.

The eight species of LYCÆNIDÆ known to occur belong to the genera *Sithon* (1), *Lycæna* (6), and ——— ? (1). *Sithon Batikeli*, Bd. sp. (= *Sithon Antalus*, Hpffr.), is found in Eastern and Southern Africa.‡ Of the *Lycænæ* three—*L. Rabe, Tsiphana*, and *Malathana*, Bd.—seem endemic; but the remaining three—*Lysimon*, Hübn., *Bœtica*, Linn., and *Telicanus*, Herbet—are remarkable for their extended range throughout Africa, and in Southern Europe and Asia. It is impossible to refer the species *Tintinga*, Bd., to any particular genus, the single specimen described by Boisduval having lost both head and body; but, as its describer seems to consider that the insect has somewhat of the aspect of the curious Javanese *Petavius*, Godt. (= *Petavia Sakuni*, Horsf.), its affinities are probably Oriental rather than African.

The HESPERIDÆ, as recorded by Boisduval, consist of 11 species, which I distribute generically thus, *viz.*:—*Cyclopides* (3), *Pamphila* (4), *Nisoniades* (1), *Ismene* (3), *Cyclopides Bernieri* and *Rhadama*, Bd., appear peculiar to Madagascar; but *C. Malgacha*, Bd., is found in Africa, as far south and west as Cape Town. *Pamphila Havei* and *Pontieri*, Bd., are recorded by Boisduval§ as natives of Natal, while *P. Coroller* and *Andracne*, Bd., are endemic. I have received *Nisoniades Ophion*, Dru., from Natal, and the species is figured and described by Drury as one from Western Africa. *Ismene Florestan*, Cram., has an African range, embracing Kaffraria, Querimba, Nubia, and Senegal;‖ *I. Ratek*, Bd., inhabits Natal; and *I. Ramanatek*, Bd., extends to Bourbon, if not to Mauritius.

The above particulars of the distribution over the globe of the Madagascarian diurnal Lepidoptera yield the following result, when the families are tabulated (see p. 652) :—

From this table it is apparent that 39, or rather more than half, of the butterflies of Madagascar are African; and of these 39 species, 27 (nearly one-third of the Rhopalocerous Fauna) inhabit no other region besides Africa. Of the remaining 34 (no less than 28 of which are endemic), 1 (*Hestia Lyncea*) is an Asiatic form; 22 show

* For this fact I am indebted to Mr. Horace Waller, of the late Zambesi Mission, who has shown me a *Libythea*, closely allied to *L. Myrrha*, Godt., taken by him on the river Shirè.

† E. Doubl., 'List Lep. Ins., Coll. Brit. Mus.,' pt. ii., p. 3.

‡ *Batikeli* will most probably be determined as a variety of *Isocrates*, Fab., a well-known Indian species.

§ In Appendix to Delegorgue's 'Voyage dans l'Afrique Australe, &c.,' p. 594.

‖ See Hpfr., *op. cit.*, p. 414.

TABULAR VIEW OF THE GEOGRAPHICAL DISTRIBUTION OF THE BUTTERFLIES OF MADAGASCAR.

FAMILIES.	NUMBER OF ENDEMIC SPECIES.	NUMBER OF SPECIES WHOSE RANGE EXTENDS TO										TOTAL NUMBER OF SPECIES INHABITING MADAGASCAR.
		Africa only.	Mascarene Islands only.	Asia only.	Africa and Mascarene Islands.	Africa and Asia.	Africa, Mascarene Islands, and Asia.	Africa, Mascarene Islands, Asia, and Europe.	Africa, Mascarene Islands, Asia, and Australia.	Africa, Mascarene Islands, Asia, Australia, and America.	Cosmopolitan.	
Papilionidæ .	1	5	—	—	—	—	—	—	—	—	—	6
Pieridæ . .	2	5	—	—	—	1	1	—	—	—	—	9
Danaidæ . .	—	—	2	1	—	—	—	1	—	—	—	4
Acræidæ . .	6	4	—	—	—	—	—	—	—	—	—	10
Nymphalidæ .	7	5	2	—	—	—	1	—	—	1	1	17
Satyridæ . .	2	—	—	—	1	—	—	—	1	—	—	4
Eurytelidæ .	—	1	—	—	—	1	—	—	—	—	—	2
Libytheidæ .	1	—	—	—	—	—	—	—	—	—	—	1
Erycinidæ .	1	—	—	—	—	—	—	—	—	—	—	1
Lycænidæ . .	4	1	—	—	—	—	—	3	—	—	—	8
Hesperidæ .	4	6	1	—	—	—	—	—	—	—	—	11
11	28	27	5	1	1	2	2	4	1	1	1	73

decidedly African affinities; 4 (*Neptis Kikideli* and *Frobenia*, *Libythea fulgurata*, and ——— ? *Tintinga*) seem more nearly allied to Asiatic forms; while 7 exhibit no marked indications of connection with either Asiatic or African types, but may be considered as being equally related to both faunas.* The respective numbers of species inhabiting other parts of the world are, relatively to the total number of Madagascarian natives and to each other, quite what we should expect to find on the assumption that Madagascar was originally part of the great continent to which it is now adjacent. Thus while, as above shown, no less than 39 inhabit Africa, the Mascarene Islands contain 15, Asia 12, Europe 5, Australia 2, and America 2.

Before concluding, it is necessary to take into consideration the Rhopalocera inhabiting Bourbon and Mauritius, amounting in all to but 23 species. As these islands are of small size, and have been well explored, we may assume with Boisduval that few butterflies remain in either undiscovered. The 23 species are thus distributed among the

* The most remarkable examples of this double relation are the two *Euplœæ*, *E. Euphone* and *Phædone*, which, common at Mauritius and also found in Madagascar, combine the structure and aspect of the African Euplæoid species of *Danais* with those of the true *Euplœæ* of Asia. An examination of these insects has led me to regard as highly probable the view suggested to me by Mr. Bates, that the Mascarene Islands may be remnants of the region where *Danais* and *Euplœa* first became differentiated; *Euplœa* since attaining its large development in tropical Asia. It is singular that *Euplœa Gondotii*, Bd., which inhabits both Natal and the Island of Bourbon, and seems the nearest of all the African *Danaidæ* to the Asiatic *Euplœæ*, has not been taken either in Madagascar or Mauritius.

families, *viz.*:—Papilionidæ, 2; Pieridæ, 1; Danaidæ, 4; Nymphalidæ, 7; Satyridæ, 2; Lycænidæ, 3; Hesperidæ, 4. In Mauritius 21 occur, in Bourbon 18; 16 being found in both islands. All but 8 are known to inhabit Madagascar:* and of these 8 species 4 (*Pyrameis Hippomene*, Bd., *Neptis Dumetorum*, Bd., *Nisoniades Sabadius*, and *Pamphila Borbonica*, Bd.) occur in both islands; 2 (*Papilio disparilis* and *Euplœa Gondotii*, Bd.) are confined to Bourbon; while 2 (*P. Phorbanta*, Linn., and *Pamphila Marchalii*, Bd.) seem peculiar to Mauritius. *Gondotii* (of Bourbon) and *Hippomene*, *Sabadius*, and *Borbonica* (of both islands) are natives of Africa, and therefore in all probability inhabit the great intermediate country of Madagascar. This leaves us but 4 species truly endemic to the Mascarene Islands, or, omitting the 2 doubtfully distinct *Papiliones*,† only 2, *viz.*—*Neptis Dumetorum*‡ and *Pamphila Marchalii*, the latter being confined to Mauritius. Besides these 2, only 5 others (which are found in Madagascar) are wanting in Africa.

Adding to the 73 butterflies of Madagascar the 8 Mascarene species not yet discovered in the great island, we arrive at a total for the group of 81 species of Diurnal Lepidoptera, of which 47 are known to be natives of Africa, while the great majority of the remaining species exhibit unmistakable affinity to African forms.

The evidence here brought forward, incomplete as it is, and limited in its application to but part of a single order of insects, contrasts strangely indeed with that adduced by Dr. Sclater with regard to the Mammals of Madagascar. Every order of Mammalia in the island possessing more than a single representative (the bats only excepted), presents *several endemic genera*, some of which exhibit the most profound modification of structure. Among the Lepidopterous insects, as far as the Rhopalocera are concerned,§ not one new genus has been discovered. While the relations between the Mammals of Madagascar and Africa are shown to be few and remote, and not one species is with certainty known to inhabit both regions, the very strongest affinity exists between the butterflies, more than half of the insular species, and 31 of the 33 genera, being indigenous to Africa.‖ This seems the more remarkable when one considers the much greater facilities for modification, during an equal lapse of time, which insects, numerous in individuals and rapid in succession of generations, would appear to present as contrasted with the comparatively scarce and slowly-

* This supposes *P. Phorbanta* and *disparilis* to be distinct species from each other and from *P. Nireus* and *Epiphorbas;* otherwise the number would be 6.

† The abnormal coloration of the ♀ *Disparilis* is very remarkable, and looks very like a modification, now in progress, of the *Papilio* in imitation of *Euplœa Gondotii*, the only other large butterfly inhabiting Bourbon.

‡ Taken by Mr. Layard in Mauritius.

§ Almost the same might be affirmed of the whole order, for of the 35 genera of Heterocera given in the 'Faune de Mad., &c.,' only one, *Borocera*, Bd. (closely allied to the African *Megasomæ*), appears endemic, unless *Sindris*, Bd. (given as a genus of Tineina), be peculiar to the island.

‖ In connection with this it is an interesting fact that *Acræa*, so typical and highly-developed an African group, presents more species in Madagascar than any other genus.

breeding Mammals. It is true that butterflies might continue to find their way from Africa to the island across a space of sea which had long since proved an impassable barrier to any but aërial Mammalia, but the influence which might thus be at intervals brought to bear on the insular Rhopalocera would be very slight, for the idea of constant or long-continued migration from the mainland is forbidden by all recent observation.*

In conclusion, I would earnestly request all zoologists to contribute the results of their researches towards the more complete knowledge of the fauna of Madagascar. Dr. Sclater's interesting deductions from a consideration of the Mammalia, require abundant confirmation from investigation of other groups in the island fauna, before acceptance can be given to them. The subject is one of the deepest interest; and it is only by a careful analysis of what is known of all the forms of Madagascarian life that we can attain to any conclusions as to the original derivation and existing relations of this most remarkable fauna.

* It is remarkable how constant nearly all butterflies, including those of the highest powers of flight, are to localities of very limited extent; and much care and investigation must be exercised before naturalists can attribute the extraordinary gatherings, occasionally witnessed, of certain species of *Pieridæ* to any migratory instinct.

CHRONICLES OF SCIENCE.

1. AGRICULTURE.

An unusually dry summer has brought into prominence several agricultural topics of importance, in which the uses and economy of water are concerned. Thus, it has entirely justified those who advocate drainage and deep tillage as really conservative of the water supply on which a growing plant depends. We have dug in well-drained land a hole five feet deep in a turnip-field, and from the bottom of it clods of earth have been brought up full of fibres of the turnip-root, easily recognizable by their taste. These fibres went far below the artificial drainage of the subsoil; but the vigorous vitality to which such deep growth was due was itself, no doubt, owing to the wholesome condition for the plants in which that drainage had placed the upper layer of soil. In this indirect way, as well as by the direct improvement and increased capacity as a storeroom which drainage and deep tillage confer upon the upper soil, do these operations increase the ability of plants to withstand a drought. That of the past summer has in nothing shown itself more plainly than in the prominent appearance of the dark, fresh green of deep-rooted plants, as the thistle and the clover plant, amongst the brown parched, surface-feeding grasses, which have been soon dried up. And anything which gives to cultivated plants a deeper, larger, fuller store on which to draw for supplies, is in cases like the present season especially beneficial.

No doubt it is owing to this better tillage of the country generally, that the drought has not proved more injurious to the seed crops of the past harvest. Notwithstanding that our grain crops had already pretty fully established themselves before the commencement of the dry weather, we might fairly have expected it to have been more injurious than it has proved. The produce of these crops, though nothing like that of 1863, has not been altogether unsatisfactory. Of 200 returns to the 'Agricultural Gazette,' indeed, from different parts of the country, only 20, 47, and 12 respectively, of wheat, barley, and oats, declare the crop to be above an average one; but one-half of the reports of wheat, and more than one-half of those of barley, state the yield to be an average. Oats, beans, and peas are undoubtedly much below an average yield this year. But this, and the inferior produce generally of the corn crop, may be attributed rather to the cold weather of June, than to the drought of May, June, and July.

The subject of summer irrigation is another point to which the weather has given importance. The experience of our sewaged meadows during the past season has not been so favourable in this respect as might have been expected. It appears that the Italian ryegrass, the plant by which sewage has hitherto been chiefly utilized, requires a moist, cold atmosphere, as well as a well-fed, cool, moist soil, to ensure a luxuriant succulence of growth. The Beddington meadows, which receive the waste of Croydon, and which in May presented such a wonderful coat of grass as the result of irrigation—30 inches high and as thick as it could stand, and weighing 12 or 14 tons per acre—have not yielded by any means so well at their second and third cuts this summer, notwithstanding the flood of filthy water which at intervals has been poured over them. The tendency of the plant to form its seed spike seems irresistible in hot, dry weather, however the growth of grass may be urged by irrigation of the soil; and a first cut, of 10 to 14 tons per acre, is followed by one of 7 or 8, and that by one of 4 or 5 tons in a hot July or August. This must be taken into their calculations by those who propose to utilize the sewage of London on the low-lying lands of Kent and Essex, two of the driest counties in the island.

The drought has produced a protest from Mr. Bailey Denton, C.E., in the form of a memorial to Sir George Grey, on the water economy of the country, and on the better uses of our rainfall. Mr. Denton proposes that agricultural proceedings with reference to that matter should be made subject to some central control. Thirty inches of rain, or thereabouts, fall annually in this island. This wets its surface, which dries again and sends back so much into the air. It finds its way, by various surface channels, runnels, brooks, rivulets, and rivers, to the sea. It sinks through its surface to various depths, taking always the path of least resistance to that downward passage which gravity imposes, until at length the passage of least resistance leads to the re-appearance of this portion of the rainfall in springs at various points below that where it sank into the ground. Now, of these two latter portions of the rainfall, various uses are made. They swell our rivers, which are thus along many miles of their course made available as carriers; they fill our mill-streams, and their weight is thus turned to account as power; they provide drink for our live-stock and our population, and they feed our plants. But the surface on which the rain-water falls is covered with plants. The cultivator of these plants is thus the first owner of this water, and he is more and more awakening to the immense value of this property, and to the greatly enhanced services which, if properly directed, it can render to him as a grower of these plants. Guided by the better knowledge of this subject which now prevails, every man, either the owner or the hirer of this surface, is dealing with the water which falls upon it for his own exclusive benefit. Either each estate by itself, or it may be even each field by itself, is so drained that the rain passes through the soil and subsoil for use, instead of over its surface to waste; and after being made useful as a feeder of the plants grown in and on the soil, it is thereafter provided with as easy and as speedy an exit as possible. The field or the estate is drained, and thereafter the water, being done with, is dismissed. Now, even as regards an estate, and still more as regards a province or a district, there is room for the use of water after it has done its duty as feeder of the plants. It is applicable as water supply for animals; it is even available again in irrigating and so in feeding plants upon a lower level. But our outfalls are every day becoming more direct and rapid in their action. Rain which used to drag sluggishly downwards through meandering streams, runs straight out to the sea. Floods, rather the result of this arterial drainage than of parallel subsoil drains, follow excessive rainfalls more immediately than they used to do. And unexpected as it may be, the influence of agricultural drainage becomes apparent on our springs, our mill-streams, and our rivers. Mr. Bailey Denton therefore urges on the Home Secretary that inquiry should be made into this subject before this piecemeal drainage of the land shall have injured what he considers the imperial and general interests of the country, in an annual water supply. It is urged that the perennial water supply is, under existing management, gradually diminishing; that it is, moreover, becoming irregular—floods and droughts more rapidly alternating; that properly conducted, on the other hand, under-drainage is capable of securing greater regularity and abundance of the water supply—certain districts subject to seasonal drought being capable of supply by the storage of the water discharged from drained land during winter and spring. And there are other considerations urged why an inquiry should at once be directed by the Government into the effect of under-drainage on our river systems, and generally into the larger question of the water economy of the country.

We see that the 'Agricultural Gazette' calls attention to that curious illustration of the natural compensating powers of our climate in the case of drought, which it believes the dew-ponds of our chalk downs to present. We do not know if exact inquiry has been made by any scientific man into the phenomena of the Berkshire dew-pond, but the subject seems well worth investigation. Perched on the very summit of a chalk down, made an impervious cup, and filled artificially in the first instance, it seems to supply so large a quantity of water daily to the flock frequenting it, and is at the same time so exposed to loss by evaporation, that a great increment by a deposit of dew upon its surface (possible enough in cases where a moist southerly wind, for example, may be slowly passing over a hill top during a clear night, when the cooling process by radiation is excessive) seems the only possible explanation of the rarity of its entire exhaustion during the summer months. That, at all events, is the popular explanation of the phenomenon, and it is quoted by the 'Agricultural Gazette' as an illustration of the compensating powers which, in a dry season, our climate must everywhere possess.

Whatever the difficulties or injury inflicted by a prolonged summer drought, it does not appear that they at all weaken or diminish those evidences of agricultural energy and prosperity which the exhibitions of our great agricultural societies have evinced. The annual meetings of the English, Scottish, and Irish National Agricultural Societies have been unusually illustrative of our rapid progress in the field. In particular, at the Newcastle meeting of the English Society, the efforts of implement manufacturers and of stock farmers were well illustrated. "Agriculture," as one reporter has it, "may be said to begin with the tillage of the soil, and end with the manufacture of meat; and Mr. Fowler's steam-plough standing at one end of the manufacture, and Mr. Cruickshank's short-horn bull 'Forth' standing at the other end, may be thus considered to include between them its whole scope, extent, and range. Every line upon the scale which separates these extremes has been well represented at this meeting, but the best and most numerous illustrations of the whole are those of tillage implements on the one hand, and short-horn stock upon the other. Never before has so good a collection or so thorough an examination of tillage implements been made, and never before have better classes of short-horn cattle been exhibited."

The principal novelty on the ground here was Mr. Fowler's new plan of applying steam-power to the cultivation of the land, to which the judges awarded the Society's head prize. He succeeds here in making two of the ordinary small threshing-engines which are everywhere employed throughout the country, stationed one at each end of the furrow where the steam-drawn plough is working, to combine their force upon it. The engine which the plough is leaving is pulling it as well as the engine which it is approaching. The wire rope is laid around the horizontal clip-drums underneath each engine, and its ends are fastened in the usual way upon the gearing of the plough in front of it and behind it on drums there, which, gearing into one another, are so arranged that any pull upon the plough by the rope in front resolves itself to some extent into a tightening of the rope behind it. This ensures that the rope is always taut around both the engine-drums; and the consequence is, that when both engines are at work, they are each pulling at the rope, and each is contributing its force to the line by which the plough or cultivator is being drawn. Very good work was made at Newcastle by Fowler's apparatus thus employed, and this plan is evidently a step in advance upon the double-engine system which Fowler as well as Savory has hitherto adopted. Where two engines are employed, and only one is in use at a time, each must be of double power, and the waste by radiation is constant in the case of each, notwithstanding that each is only half its time at work. The fuel consumed must therefore, in such a case, be excessive. And there is this further advantage in the double-engine system when the two engines co-operate, that neighbours may combine their engines for work of any special difficulty, the engines being severally at the same time of just the right power both for threshing purposes and for ordinary light-land cultivation.

We may mention, among the events of the past summer, the publication of extremely suggestive lectures on Dairy Farming, which had been previously delivered before the Royal Agricultural College, by Mr. Harrison, C.E., of Frocester Court, Gloucestershire. In addition to the mere detail of good practice which these lectures describe, they enumerate a great many facts and develope very many ideas and suggestions well calculated to excite the attention and the thought of those to whom they were addressed. Among these we may mention that the author points out that the dairy districts are, for the most part, confined to those geological formations which were deposited during the existence of vertebrate animals upon the earth. Phosphates applied to the soil bring about the growth of clovers among the grasses, and they are also especially necessary on dairy farms, as evidenced by the quantity of them which exists in the milk or cheese sold off such farms; and it is a curious circumstance that the cheese-dairying especially should be confined to those geological districts where the formation contains not the mere stony remains of shell-fish and crustaceans, but the *bone-dust* of a higher order of animals. Among the other facts specified in these lectures is the existence and the uses of enormous quantities of earthworms in the soil of grass lands. An experiment over a considerable surface of land led to the estimate of their quantity at 1,000 lbs. weight per acre; and it is declared that so large a quantity must, by its effect on the texture of the land, and by its ultimate addition to the very substance of the land, be an important contribution to its fertility.

Some discussion has arisen in connection with dairy-farming in Cheshire, from a paradoxical speech by Sir H. Mainwaring, Bart., at a recent agricultural meeting, when he set himself to arouse thought and excite controversy amongst the dairy-farmers of that county by the confident utterance of what appeared to them, as it does to us, in direct opposition to both local and general agricultural experience. His assertions were that drainage, bone-dust, and broad-breasted bulls had been the ruin of the Cheshire dairy-farmers. But the facts unquestionably are that the drainage of the pasture-lands of Cheshire, the application of bone-dust to them, and the short-horn cross upon their dairy-cows, have been of the greatest agricultural service in that county! Sir H. Mainwaring's idea that over-drainage injures grass is, however, to some extent, countenanced by the first or second year's experience of it; the wet-land grasses disappear before the better grasses suitable to the improved condition of the soil make their appearance; but the ultimate influence of drainage upon grass-lands is rarely unsatisfactory. The use of bone-dust, again, tends in a very remarkable degree to the improvement of the pastures by the extraordinary development of the clover-plant, which immediately follows. And there cannot be a doubt that the Welsh or long-horned cattle, formerly common on the Cheshire farms, have been greatly improved and, in some instances, usefully displaced by the short-horn breed, which stands at the very head of the cheese-producing breeds of the country.

We have only one more fact to add to our quarterly summary of agricultural intelligence. The Royal Agricultural Society of England has offered 50*l.* for a prize on middle-class education, having especial reference to those who are dependent on the cultivation of the soil. They were informed by Mr. Morton, at the general meeting held last December, that although by their charter they had been incorporated for the very purpose of promoting the education of the farmer, yet that particular object specified in their charter had hitherto received from them no attention whatever. A committee was thereafter appointed to consider in what way the "seventh national object" specified by the charter could be promoted, and this is the result of the committee's inquiries. It seems to us that the offer of a prize on middle-class education is entirely abandoning the subject to which they are committed by their charter; and that they will properly discharge the duties which it imposes on them only by promoting the professional education of the agriculturist—this being done by giving encouragement and guidance to the existing means of agricultural education.

II. ASTRONOMY.

(Including the Proceedings of the Royal Astronomical Society.)

We have but few important advances to chronicle in general astronomy, although a glance at the proceedings of the Astronomical Society for the last few months will show that slow but sure progress has been made by English observers. We may commence by reminding our readers that a prize of 200 ducats (about 90*l.*) has been offered by the Academy of Sciences at Vienna for the best research on the movements of the fixed stars. The last day for sending in the papers is fixed for December 31, 1865. We cannot help thinking that the time here allowed is far too short. The base line used by astronomers in investigating the movements of these distant bodies being the diameter of the earth's orbit round the sun, it will take six months to accumulate merely one set of observations, and as the minuteness of the observed movements renders it highly desirable to verify the first obtained data by numerous subsequent observations, it is scarcely likely that any new and striking measures of parallax can be included in the memoirs, unless, indeed, the principal observations have already been made by the competing astronomers. In such a case as this science would be more advanced by offering a larger sum as a prize, and allowing the time to extend to five or six years.

Our readers are doubtless well aware that a new Astronomical Society was founded last year at Heidelberg. This society is essentially international in its character, and numbers amongst its members not only German, but also English, French, Italian, and Russian astronomers. Several of its most eminent members are dividing the work between them; some are investigating the disturbances which have taken place in the movements of Mercury, Venus, Mars, Jupiter, Saturn, and Uranus, in some cases going back as far as 1770. Others have divided the asteroids amongst them, each member taking a planet under his care, and observing its motions periodically. A society of earnest workers acting in this manner is more likely to further the objects of their science than are any two of the so-called learned societies as at present constituted.

The star 40,196 (Lalande) is noted for its singular variability, and M. Goldschmidt still continues his accurate investigations on its changes. The result of his observations is, that it accomplishes its cycle in a period of 197 days. It remains nearly invisible for 61 days, it then gradually increases in luminosity for 56 days, remains stationary for a perceptible period, then diminishes for 78 days, and finally disappears.

At the last meeting of the French Association for the advancement of astronomy and meteorology, founded by M. Leverrier, a new reflecting telescope was exhibited, having a speculum nearly a yard in diameter. It is of glass, silvered by chemical means, the process having been explained to the meeting. We understand that these reflectors, first employed by M. Foucault, are rapidly making way in this country, their cheapness, lightness, and the ease with which they can be resilvered when tarnished, rendering them formidable rivals to both refractors and reflectors of the ordinary kind.

The subject of meteorites is still being pursued by M. Heidinger, of Vienna, who has so thoroughly identified himself with the investigation of these bodies. In a letter to M. A. Quêtelet, of Brussels, he gives some interesting particulars of the fall of a supposed aërolite at Inly, near Trebizond. It fell in an easterly direction in December last with a terrific explosion, resembling the discharge of hundreds of pieces of ordnance. Some pieces supposed to have formed part of it have been forwarded to Vienna, but from the examination already made of them, their origin seems to be rather terrestrial than cosmical. Professor Kenngott, director of the Mineralogical Museum of Zurich, has lately forwarded to M. Heidinger a specimen marked native iron from Styria, but which he suspected was meteoric. The director of the Imperial Museum at Vienna had it cut and polished. Subsequent treatment with acids left no doubt of its cosmical origin. It also contains crystals which appear to be olivine and pyrosene, and its general character seems to identify it with the meteorite which fell many years back at Steinbach, in Saxony. It would be interesting if the directors of museums would submit to similar tests any specimens of so-called native iron that they may have in their possession.

The Royal Astronomical Society.

Further observations of the newly-discovered satellite of Sirius have been communicated to the Society during the last few months. M. Otto Struve has determined, from observations extending from March 16, 1863, to March 28, 1864, that its annual change of distance is equal to $+0''\cdot77$, and its annual change of position $-5°\cdot7$. He considers that on the first glance we are led to the conclusion that the hypothesis of accidental juxtaposition of the two stars is by far the most probable, a conclusion which is even strengthened by some of Mr. Bond's observations. Although a strong objection against their merely optical association must be derived from the circumstance that Herschel, at the end of the last century, when with this supposition the small star ought to have had a distance of about one minute from Sirius to the south-west, never noticed its existence, though it is well known that about that time he frequently observed Sirius as a test object for the quality of his mirrors. After giving several other arguments on each side of the question, Professor Struve concludes that he must suspend judgment on the physical connection or merely optical juxtaposition of the small star until next year. In reference to this paper Mr. Dawes remarked that the star was visible in strong twilight, and he therefore conceived that it was not so very small in itself, but only appeared so in consequence of its proximity to the prodigiously bright star of which it was the companion.

In an elaborate and important paper on the probable error of a meridional transit-observation by the "eye and ear," and chronographic methods, read by Mr. Dunkin at one of the recent meetings of the Society, he comes to the conclusion that the chronographic observations of a transit are attended with much less probable error than an eye-and-ear observation; the personal discordances between the different observers are also comparatively small by the former method, and the general steadiness of observing by it is very remarkable. In the results for right ascension the probable error for chronographic transits is also much less. Some discussion followed the reading of this paper. The president, Dr. De la Rue, referred to an improvement upon a proposal made some time ago by Professor Wheatstone for increasing the accuracy of transit observations. This was that a system of wires should be arranged in the transit instrument, which, when the star was brought between them, should follow its movement; and when the star passed the optical axis of the instrument or any number of known points from that axis, then the chronographic signal would be made by the wires making electrical contact, so that a number of records would be obtained independent of the will of the observer. Col. Strange mentioned that the Paris astronomers had expressed themselves decidedly against the chronographic method; he did not, however, agree with this, and had therefore, with the sanction of the Government, ordered a complete chronographic apparatus for the use of the Indian survey. Col. Strange further remarked that Professor Wheatstone's suggestion of having a telescope so constructed that the star should be automatically followed over the wires had already been carried out. When at the Paris Observatory, he had examined an apparatus of this description made by M. Redier; the wire was carried so steadily across the field, so exactly with the same velocity as the passage of the star, that the intersection of that star with the wire was a matter of the most perfect ease and certainty; in fact, there was ample time for the observer to call an assistant to verify the observation before leaving the instrument. Mr. Dunkin in reply to the opinion that the chronographic system tended to produce bad eye-and-ear observers, remarked, that at the Royal Observatory, observers, who had practised the chronographic system for ten years, could still, when the apparatus was out of order, take eye-and-ear observations with as much accuracy as formerly.

The appearances of the solar surface are still attracting great attention. The Rev. W. R. Dawes speaks very decidedly as to the total absence of any objects on the photosphere which could be compared to willow-leaves in their form. He has for many years been familiar with granulations or granules of forms and sizes so various as to defy every attempt to describe them by any one appellation. Upon more quiet and perfect view of these granulations, it appears that they are not individual and separate bodies of a peculiar nature, but only different conditions as to brightness or elevation of the larger masses forming the mottled surface. Between the granules the shaded portions are in many places pretty thickly covered with dark dots like *stippling with a soft lead pencil*, but he was struck with the extreme rarity of a long and narrow shape among the granules with which the surface of the sun is covered. They may perhaps be sometimes compressed into a longer form under the influence of the same forces which produce the longer threads or *straws* on the penumbra, but one of the most striking features is the entire absence of uniformity in the brighter portions with respect both to their size and shape. Mr. Dawes further said, that one of the most remarkable things connected with the matter, was that whereas these granules, or "rice grains," were easily seen,—a small telescope with a power of 40 or 50 bringing them into view,—Mr. Nasmyth should have accepted them as his "willow-leaves," which he says are so difficult to see with an 8-inch aperture. Mr. C. G. Talmage confirmed Mr. Dawes's statement. Since 1861, he had most carefully scrutinized the surface of the sun both at Nice, at Paris, and in England, with 4-inch, 6-inch, and 8-inch object-glasses with powers up to 500, but had never seen the slightest trace of "willow-leaves," "rice grains," or "thatch." In the discussion which followed the reading of these papers, Dr. De la Rue remarked, that it is to the sun himself and to other observers that the confirmation or non-confirmation of Mr. Nasmyth's discovery must be left; he himself maintained, notwithstanding what had fallen from other astronomers, that it was a substantial discovery.

At the end of last year the assistant-secretary of the Society, Mr. Williams, gave an abstract of the record of thirty-six eclipses in the Chinese historical work called 'Chun Tsen.' Mr. Williams had converted the Chinese dates into dates according to the Julian calendar. The Astronomer-Royal has lately compared the 'Chun Tsen' eclipses with those calculated in the French work entitled 'L'Art de Vérifier des Dates,' and he finds that, of the thirty-six eclipses, thirty-two agree with the computations of modern theory, whilst in the remaining four it is very probable that there is an error in the Chinese record.

Some very important notes on the binary star, α Centauri, are given by Mr. E. B. Powell. He invites attention to the important portion of the orbit now about to be described, *viz.* the part in the immediate neighbourhood of the lesser maximum of distance. If this maximum be accurately determined, one most prominent feature in the path will be fixed; and then, as the companion will revolve with continually increasing rapidity till its distance from the primary diminishes to 1″ or less, a really excellent orbit will be calculable in 1870 or thereabouts. Now that so much discussion is going on respecting the changes which are supposed to have taken place in nebulæ, it may be of interest to record that Mr. Powell considers that decided changes have taken place in the nebula about η Argus. In 1860, the whole nebula had faded away very considerably, and it had altered its form, the nebulous matter having receded so as to leave open the southern end of the lemniscate vacuity. Mr. Abbot first published the fact that η is no longer in the dense portion of the nebula where it was seen by Sir John Herschel.

In 1857 the Astronomer-Royal made a communication to the Astronomical Society on the means available for correcting the received measure of the sun's distance from the earth. Among the different subjects of observation applicable within some years to this object, he particularly indicated the transit of Venus, December 6, 1882, treated by the method of comparison of duration of transits at different places, as one meriting most careful consideration. The Society has lately been favoured by the learned professor with a further communication on this transit, illustrated with orthographic projections of the illuminated sides of the earth for ingress and egress. From these it is seen that on the seaboard of the United States of America, the duration of transit would be shortest. The possible maximum of shortening being 2·00, that at the United States is represented by 1·78. The Southern States, as far as the Gulf of Mexico, would be almost as favourable, and would have the advantage of a higher sun at egress. Bermuda would be also a very good place, the whole shortening there being 1·8. The circumstances therefore are exceedingly favourable for the selection of observing stations at which the duration of transit will be much shortened. The choice of stations where the duration of transit will be longest is more limited, and the practical difficulties rather greater. The most favourable position that can be found is between Sabrina Land and Repulse Bay, where the lengthening of the transit would be represented by 1·61—a very large amount; the geometrical possible maximum being 2·00. This point near Sabrina Land being the only one very suitable for the observation, the Astronomer-Royal thinks it very desirable that a reconnaissance should be made of different points on the Antarctic continent, and that it should not be long deferred. The first locality to be examined is that in 7^h E. longitude between Sabrina Land and Repulse Bay, the points to be ascertained being 1st, whether the coast is accessible on the 6th of December; 2nd, whether a latitude of 65° can be reached; and 3rd, whether the sun can usually be seen well on December 6th at 2^h and 8^h Greenwich mean solar time. Should the answer to the first or third of these questions be negative, then it would be proper to examine other portions of the south continent, say in longitude not very different from 5^h west, but with no particular restrictions except that of gaining the highest possible south latitude. And the only point for inquiry would be, how well the sun can usually be seen on December 6th at the hours above named.

Referring to an adverse criticism which Messrs. Stone and Carpenter made upon Professor Bond's drawing of the nebula of Orion, in which these gentlemen considered it was not so accurate as that of Sir John Herschel, Professor Bond has communicated to the Astronomical Society a detailed defence of his own drawing, and a notice of that of Sir J. Herschel. He appears to show very satisfactorily that Messrs. Stone and Carpenter have not been altogether warranted in their unfavourable notice, as micrometric measurements prove that, in several instances, Herschel's drawing is less accurate than Bond's. It would be more satisfactory if some independent observer were to examine the matter minutely, for it is really important, in view of the questions which have been raised respecting the reality of changes in the aspect of the nebula. The reading of these remarks gave rise to a short discussion, in which Mr. Stone, Dr. Winnecke, and the Rev. C. Pritchard took part. It was generally agreed that, from the acknowledged ability of Mr. Bond, his drawing will probably become the standard of reference for the present epoch ; but it was most important that attention should be directed to all suspected deviations of that drawing from accuracy, in order that they might now be settled while there is an opportunity of doing so.

Some very beautiful photographs of the sun, taken by the Ely Helioautograph, were exhibited at the same meeting by Professor Selwyn. Some of them were $6\frac{5}{8}$ inches in diameter, and contained spots and faculæ very clearly marked. He considered that his photographs did not support a result obtained by Mr. Stewart, who, from an examination of the sun pictures taken at Kew, considered that it was a nearly universal law that the faculæ belonging to a spot appear to the left of that spot. Professor Selwyn believes that the faculæ surround the spots in the same way as the edges of a crater surround the cavity of a crater, not favouring one side or the other, but lying fairly round them. A continuous series of solar photographs cannot fail to give the means of proving or disproving such statements.

We have already mentioned the series of Chinese eclipses communicated to the Society by Mr. John Williams. This gentleman, a profound Chinese and Japanese scholar, has more recently communicated another series, from B.C. 481 to the Christian era, which he has extracted from a Chinese historical work entitled 'Tung Keen Kang Muh,' in 101 volumes, first published during the Myng dynasty, about 1473. The dates have been carefully verified by a comparison with a set of chronological tables published in Japan, which supply not only the Chinese cycles and their years, arranged according to their *Kea Tsze* system, but also the years in the European system, answering to their cyclical years. The work of exhuming these records of eclipses must be very laborious, and Mr. Williams deserves great praise for the service which his linguistic talents enable him to render to astronomical science.

Respecting the bright band bordering the moon's limb in photographs of eclipses, Professor Airey described some experiments which he says leave no doubt on his mind that the phenomenon in question is a mere nervous irritation of the retina, produced by the view of the conterminous black and white portions of the photograph.

An elaborate mathematical paper on shooting-stars in March, by A. S. Herschel, Esq., cannot be given in abstract.

R. Hodgson, Esq., has communicated to the Society a note on the achromatic object-glass, illustrated with several diagrams, in which he shows how wide and large have been the variations made by foreign opticians, whilst the form adopted by English opticians is the same as that used by the inventor, John Dolland, in 1758. A form adopted by Steinheil in 1860, computed from a paper by Gauss published in 1817, is spoken of very highly as admitting of an increased aperture for a given focal length. With reference to the discovery of achromatism, it is an interesting fact that in a curious old folio volume, entitled 'Zahn's Optics,' printed at Nuremberg in 1702, amongst other diagrams one is given of a pair of lenses exactly similar to an achromatic object-glass of the form adopted by Dolland. Mr. Hodgson speaks in high terms of the regularity and great excellence of the optical glass now made by Messrs. Chance, of Birmingham.

The Rev. W. R. Dawes has announced the curious fact, that the small star *s. p. μ Herculis*, which in the year 1856 was discovered by Mr. Alvan Clark to be close double, is a *binary* system, the variation in position amounting to about 18° within the last five or six years.

Mr. Pogson now considers that the identity of his last new planet with *Freia* is quite established, and the name *Sappho* is again at liberty for future use. He has now provided another candidate for the name, this time most certainly and evidently a new planet. Its magnitude is 10·4.

Mr. De la Rue reports most favourably of the performance of a telescope of new construction, sent by Dr. Steinheil for exhibition at his reception held at Willis's Rooms on June 11. The objective has an aperture of about 4·2 inches, and a focal length of about 40 inches. Dr. Steinheil is now engaged upon an object-glass composed of three lenses of 6 inches aperture, and only 30 inches focal length.

III. BOTANY AND VEGETABLE PHYSIOLOGY.

Dr. Asa Gray makes the following remarks in regard to *Calluna vulgaris* as an American plant:—

The earliest published announcement that we have been able to find of *Calluna vulgaris* as an American plant is that by Sir William Hooker, in the Index to his 'Flora Boreali-Americana' (ii. p. 280), issued in 1840. Here it is stated that—"This should have been inserted at p. 39, as an inhabitant of Newfoundland, on the authority of De la Pylaie." Accordingly in the seventh volume of De Candolle's 'Prodromus,' to the European habitat is added "*Etiam* in Islandia et in Terra Nova Americæ Borealis." But it does not appear that Mr. Bentham had ever seen an American specimen. He also overlooked the fact (to which Dr. Seemann has recently called attention) that Gisecke, in Brewster's 'Encyclopædia,' records it as a native of Greenland. No mention of it is made by Dr. Lang, in his enumeration of the known plants of Greenland, appended to Rink's 'Geographical and Statistical Account of Greenland,' published in 1857; from which we may infer that the plant is perhaps as rare and local in Greenland as in Newfoundland, or even in Massachusetts. In September, 1861, Dr. Gray announced the unexpected discovery, by Mr. Jackson Dawson, of a patch of Heath in Tewksbury, Massachusetts; adding the remark, that "it may have been introduced, unlikely as it seems; or we may have to rank this Heath with *Scolopendrium officinarum*, *Subularia aquatica*, and *Marsilea quadrifolia*, as species of the Old World so sparingly represented in the New, that they are known only at single stations—perhaps late-lingerers rather than new-comers." And when, in a subsequent volume of the 'American Journal of Science and Arts,' Mr. Rand, after exploring the locality, gave a detailed account of the case, and of the probabilities that the plant might be truly native, we added a note to say that the probability very much depended upon the confirmation of the Newfoundland habitat. As to that we had been verbally informed, in January, 1839, by the late David Don, that he possessed specimens of *Calluna* collected in Newfoundland by an explorer of that island. Our friend, Mr. C. J. Sprague, however, after having in vain endeavoured to find in any publication of Pylaie's any mention of this Heath in Newfoundland, and having ascertained that no specimen was extant in Pylaie's herbarium, or elsewhere that he could trace, naturally took a sceptical view, and in the 'Proceedings of the Boston Natural History Society' for February and for May, 1862, he argued plausibly, from negative evidence, against the idea that any native Heath had ever been found in Newfoundland or on the American continent. It is with much interest, therefore, that we read the following announcement by Dr. Hewett C. Watson: "Specimens of *Calluna vulgaris* from Newfoundland have very recently come into my hands, under circumstances which seem to warrant its reception henceforth as a true native of that island. At the late sale of the Linnean Society's collections in London, in November, 1863, I bought a parcel of specimens, which was endorsed outside, 'A Collection of Dried Plants from Newfoundland, collected by — McCormack, Esq., and presented to Mr. David Don.' The specimens were old, and greatly damaged by insects. Apparently they had been left in the rough, as originally received from the collector; being in mingled layers between a scanty supply of paper, and almost all of them unlabelled. Among these specimens were two flowerless branches of the true *Calluna vulgaris*, about six inches long, quite identical with the common Heath of our British moors. Fortunately, a label did accompany these two specimens, which runs thus: 'Head of St. Mary's Bay.—Trepassey Bay, also very abundant.—S.E. of Newfoundland, considerable tracks of it.' The name '*Erica vulgaris*' has been added on the label in a different handwriting. All the other species in the parcel (or nearly all) have been recorded from Newfoundland, so that there appeared no cause for doubt respecting the *Calluna* itself. And, moreover, the collector had seemingly some idea that an especial interest would attach to the *Calluna*, since in this instance he gave its special locality, and also added two other localities on the label. But there is very likely some mistake in the name of the donor to Mr. Don. It is believed by Sir William Hooker that he was the same Mr. W. E. Cormack whose name is frequently cited for Newfoundland plants in the 'Flora Boreali-Americana.' This gentleman was a merchant in Newfoundland, to which he made several voyages. We should recollect that the *Calluna* advances to the extreme western limits (or out-liers) of Europe, in Iceland, Ireland, and the Azores. The step thence to Newfoundland and Massachusetts, though wide, is not an incredible one."

Without doubt these are the very specimens referred to by Mr. Don, then curator of the Linnean Society; and now that the stations where they were collected are made known, we may expect that the plant will soon be rediscovered, and its indigenous character ascertained.

M. Cahours finds that fruits, such as apples, oranges, and lemons, after being pulled, absorb a portion of oxygen from the air, and give out carbonic acid. The quantity of the CO_2 given off is greatest in darkness and at a high temperature. Similar phenomena take place when the fruits are placed in oxygen gas. When the fruits begin to decay, then a large quantity of CO_2 is formed, so that the atmosphere around the fruits becomes loaded with it and very unwholesome. This occurrence depends on a chemical change in the juices of the fruits. Carbonic acid is given off by decaying fruits when placed in azote, proving that it is not produced by absorption of the oxygen of the air. The change in medlars, called by Lindley "bletting," is similar, and is accompanied with fermentation, causing sugar to be converted into alcohol, carbonic acid, and an ether which gives the peculiar aroma to the fruit.

Dr. Seemann has made a list of 279 species in which double flowers occur. Of these, 234 are exogens and 45 endogens. Of the exogenous species, 166 are polypetalous, 66 gamopetalous, and 2 apetalous. The vast majority of plants producing double flowers occur in the Northern hemisphere. Not a single species with double flowers has been noticed in Polynesia and Australasia. A few occur in South Africa and South America.

Mr. Carey Lea, of Philadelphia, finds that ozone checks the growth of the roots of plants, and that it prevents the formation of mould. The ozone which he used was generated by the action of sulphuric acid upon chameleon mineral.

It has been found that vegetable ivory in contact with concentrated sulphuric acid assumes a fine red colour, almost equal to magenta. At first it is pink, but gradually becomes deeper until it attains a purple when the acid has been allowed to act for twelve hours.

Professor Braun, in the 'Proceedings of the Berlin Academy,' gives a list of 37 species of Marsilea. Of these, 4 are found in Europe, Northern Africa, and Asia; 6 in Southern Asia; 12 in Central and Southern Africa and the islands adjacent; 9 in North and South America—one of which is common to both North America and Europe; 5 in Australia; and 4 in the South Sea Islands—only 2 of which, however, are peculiar to them.

Neotinea intacta of Reichenbach, an orchid allied to *Aceras* and not unlike *Habenaria albida*, has been recently added to the Irish

Flora. It was found in the woods of Castle Taylor, in Galway, by Miss More. It has been previously known as a native of Greece, Malta, Algiers, south of Germany, and Portugal.

Goodyera repens, the northern limit of which has been recorded as Perth and Forfar, has been found recently in large quantity by Mr. Claudio L. Serra in fir woods at Dalmeny Park, near Edinburgh. *Corallorhiza innata* has likewise been found in woods near Alloa by Dr. A. Dickson, and at Denholm Green, near Cavers. *Draba rupestris* and *Sagina nivalis* have been found by Professor Balfour on Stobinnain, a mountain upwards of 3,800 feet above the level of the sea, at the head of Balquidder and close to Ben More.

In the north-western provinces of India, the following plants are used for poisoning food with the view of robbery, according to Dr. James Irving:—*Datura fastuosa* and *alba*, *Aconitum ferox*, *Cannabis indica*, *Nerium Oleander*.

Mr. Edward Tuckermann has published observations on North American and other Lichens. The Lichens are chiefly those collected by Mr. Wright in the Island of Cuba. These specimens afford a view of a tropical Lichen flora as extensive and elegant as has perhaps ever been given.

M. J. Duval-Jouve has published an account of the Natural History of the Equisetums of France, illustrated by 10 plates. In reporting upon it, Messrs. Decaisne, Tulasne, and Brongniart make the following remarks:—The genus Equisetum constitutes by itself one of the most remarkable families of Vascular Cryptogams. The peculiar external forms of these plants, the nature and disposition of their organs of vegetation, and the characters of their reproductive organs, isolate them apparently from the families near which they are placed, on account of resemblances in certain essential points of character. These plants have been long special objects of study, and of late years important discoveries have been made in regard to their mode of reproduction. The researches of Thuret, Hofmeister, and Milde, from 1848 to 1852, have shown the similarity existing between Equiseta and Ferns in their mode of fecundation. M. Duval-Jouve has extended their observations, and has issued a very complete work on the family. He has followed the development of the various species of Equisetum from the state of spore up to the fully-formed fructification. He describes the structure of the stems, the branches, and the adult roots in the different species, and points out the relations which exist among the various tissues of which they are composed. He also follows the mode of development of the tissues; the formation and multiplication of the cells, which, at the summit of the bud, determine the first evolutions of the stem; the first appearance of the sheaths, which in these plants take the place of the leaves; and the formation of the stomata and the vessels. The sheaths, which at intervals surround the stems and branches in the plants, have generally been looked upon as verticils of imperfect leaves; but M. Duval-Jouve shows that they are first formed as a continuous ring, the free border of which at a later period forms the teeth of the sheaths, and that, on this account, their resemblance to the foliar organs is rendered doubtful. The siliceous covering is considered as a secretion of the part of the epidermal cells which is in contact with the air. It is an inorganic secretion outside the cells, and resembling in some respects the waxy matter deposited on the surface of the leaves and fruits. Full details are given of the structure of the stomata; their position being limited to the parts of the epidermis which cover a parenchyma filled with chlorophyll. The vascular system of Equisetums consists of a cylinder of distinct and very regular bundles of annular or spiral vessels. Regular lacunæ also occur in the inside of these bundles, formed by the absorption of the more internal of the vessels. The development of spores resembles that of the pollen-grains, and the spiral filaments surrounding the spores are formed from the outer membrane of the spore itself. These spores when germinating produce, as in ferns, a small green irregularly-lobed frond or prothallus, called by M. Duval-Jouve *Sporophyme*. On the prothallus are produced Antheridia filled with spermatozoids or antherozoids, and Archegonia containing each a germ-cell or embryonary-cell, destined after fecundation to produce the fructiferous frond. The prothalli are usually unisexual. The expulsion of the antherozoids and their application to the Archegonia are favoured by humidity. The following species are described:— 1. *Equisetum maximum*, Lam. 2. *E. sylvaticum*, L. 3. *E. pratense*, Ehrh. 4. *E. arvense*, L. 5. *E. littorale*, Kuhl. 6. *E. limosum*, L. 7. *E. palustre*, L. 8. *E. ramosissimum*, Desf. 9. *E. variegatum*, Schl. 10. *E. trachyodon*, Al. Bra. 11. *E. hyemale*, L.

IV. CHEMISTRY.

(Including the Proceedings of the Chemical Society.)

The short space we can devote to the Chronicles of Science in this number, obliges us to condense into the smallest bulk the little we have to record of the progress of Chemistry.

Following our ordinary arrangement we may first draw attention to some experiments with oxygen, which, although made some time ago, have but recently become known to English chemists. Dr. Meissner,* of Göttingen, has devoted himself to a thorough investigation of the ozone and antozone question; and in the course of his experiments has obtained some curious results. The most singular, perhaps, is the discovery that *antozone* possesses a remarkable attraction for water, which it takes up in the shape of vapour forming a mist or cloud. This the author supposes to explain many meteorological phenomena. In the course of the experiments he also satisfied himself that ozone and antozone are produced from ordinary oxygen in

* 'Untersuchungen über den Sauerstoff.' Hanover, 1863.

equivalent proportions, and that one cannot be formed without the other, thus satisfactorily demonstrating the triple nature of oxygen. Meissner's results and opinions, however, do not pass unchallenged, and Von Babo* throws great doubt on the existence of the so-called antozone.

Some experiments by Weyl † on the combinations of ammonium deserve a passing notice. By placing potassium in contact with ammonia in a closed tube the author obtained an unstable compound in which he supposes one of the hydrogen atoms of the ammonia to be replaced by potassium. He proposes to ascertain if it be possible to obtain oxides and salts of this compound, and in this way to arrive at some conclusion respecting the metallic nature of ammonium.

Tungsten, a metal which presents some anomalous characteristics, has been made the subject of some investigations by the MM. Persoz.‡ They have not yet published their results in detail, and now only announce the discovery in the metal of several distinct radicals which give rise to various oxygen compounds, acids, and bases.

The colouring matter of the emerald has been a subject of discussion. By some the colour was supposed to be due to organic matter only; but Wöhler and Rose § have recently determined the presence of a very minute proportion of oxide of chromium to which they attribute the colour, admitting the possibility of some organic matter being present. A stone, however, which they kept for an hour at the temperature of melted copper showed no sign of alteration.

It may be worth mentioning that M. Aupin has determined the presence of silver in the water of the Dead Sea, a ton of the saline residue of which contains seven grains of the precious metal.

In organic chemistry we may announce the discovery of yet another hydrocarbon in that highly complex mixture, coal tar.|| The discovery seems to have been made about the same time by MM. Bechamp and Naquet. The new body boils at about 140° C., and M. Naquet announces its composition to be $C_9 H_{12}$. Beilstein, however, asserts it to be identical with *Xylene* $C_8 H_{10}$.

Some recent cases of poisoning have caused a considerable extension of our knowledge of vegetable poisons. Digitaline has been made the subject of investigation by several French chemists, and especially by MM. Grandeau ¶ and Lefort.** The experiments of the former were principally directed towards obtaining a ready and decisive means of detecting the poison in organic mixtures, in which he has to some extent succeeded. He has found that digitaline passes with tolerable facility through a dialyser, and may be extracted from the evaporated diffusate by means of alcohol. The most characteristic reaction he has found to be that produced when digitaline is moistened

* 'Annal. der Chem. und Pharmacie,' Dec. 1863, p. 265.
† 'Poggendorff's Annalen,' No. iv., 1864, p. 601.
‡ 'Comptes Rendus,' June 27, 1864.
§ Ibid.
|| 'Comptes Rendus,' July 6, 25, and Aug. 4.
¶ 'Comptes Rendus,' vol. lviii. p. 1048.
** 'Chemical News,' vol. x. p. 99.

with sulphuric acid and exposed to the vapour of bromine. It then instantaneously assumes an intense violet colour, varying in shade according to the amount of the substance present, but sufficiently distinct with 0·0005 of a gramme. M. Lefort's investigation was confined to the different properties of the various digitalines found in commerce; and we may say in a few words that the differences remarked were so great as to show that digitaline at the best is an extremely variable substance, the use of which as a medicine should at once be prohibited.

A lamentable occurrence at Liverpool has been the occasion of some experiments on the chemical properties of the Calabar bean by Dr. Edwards,* which will be found of great interest to toxicologists.

While on the subject of the detection of vegetable poisons we must mention that Dr. Helwig † has found that by a very carefully regulated temperature morphia, brucia, strychnia, veratria, aconitia, and atropia may be sublimed, and the microscopic appearance of the sublimate become the means of identification.

Cahours, whose experiments on the respiration of leaves and fruits we noticed in our last, has proceeded with an examination of the respiration of flowers.‡ The green parts of plants, it will be remembered, under the influence of light assimilate carbon and give off oxygen; the coloured parts, on the contrary, absorb oxygen and evolve carbonic acid.

In analytical chemistry we have but little to report. Professor Williamson and Dr. Russell detailed to the Chemical Society a new method of gas analysis, no description of which would be intelligible unless accompanied by a drawing of the apparatus employed. We must therefore refer the reader to the 'Journal of the Chemical Society' for the description.

M. Schlœsing has quite recently § published a method of estimating phosphoric acid in earthy phosphates by reducing the acid in a current of carbonic oxide, and subsequently passing the volatilized phosphorus into a solution of nitrate of silver. The phosphide of silver which is formed is then converted into phosphate and weighed. This process is not likely to meet with general adoption. The determination of phosphoric acid is, however, a very important matter, especially to the agricultural chemist, and we therefore call attention to a valuable paper on the analysis of mineral phosphates by Mr. R. Warrington, jun.,‖ which contains a detailed description of the best methods hitherto pursued.

In the technical applications of chemistry one or two important discoveries have been made. The first we may notice is that of M. Pelouze,¶ who has found that the alkaline polysulphides saponify fats as easily as caustic alkalies. This discovery may considerably

* 'Chemical News,' vol. x. p. 108.
† 'Zeitschrift für Analytische Chemie,' H. 1, 1864.
‡ 'Comptes Rendus,' June 27, 1864.
§ 'Comptes Rendus,' Aug. 22, 1864.
‖ 'Chemical News,' vol. x. p. 1.
¶ 'Comptes Rendus,' July 6, 1864.

lessen the cost of producing soaps, if some effectual means of removing the sulphur compounds should be devised.

Another discovery bearing on the same subject has been made by M. Mege-Mouries,* who notices that fats in the globular state, which is induced by agitating a melted fat with warm water containing a little yolk of eggs or even soap, are saponified by a much smaller amount of alkali and in a much shorter space of time than when in the ordinary liquid state.

The colouring matters of madder have been the subjects of some investigations by M. E. Kopp,† who has found that yellow alizarine may be separated from the common commercial green substance by agitating the latter with mineral oil, in which the yellow is soluble but not the green. Caustic soda in weak solution will now separate the madder colour from the oil, and the addition of sulphuric acid to saturate the alkali now precipitates pure yellow alizarine.

These are a few of the more generally interesting subjects which have engaged the attention of chemists within the last three months.

Proceedings of the Chemical Society.

The papers which have been read at the Chemical Society since our last publication include that by Professor Williamson and Dr. Russell, On a New Method of Gas Analysis; Professor Wanklyn, On Isomeric Hydrocarbons; Professor Williamson, On the Classification of the Elements according to their Atomic Weights; Professor Stokes, On the Detection and Discrimination of Organic Bodies by means of their Optical Properties; Mr. Schorlemmer, On the Identity of Methyl and Hydride of Ethyl; Mr. R. Dale, On the Action of Baryta on Suberic Acid; and A Description of Vacuum Experiments by Dr. H. Sprengel. The session was concluded by the reading of a discourse On the Philosophy of British Agriculture, written by Professor Way.

V. GEOLOGY AND PALÆONTOLOGY.

(Including the Progress of the Geological Survey of the United Kingdom.)

The most important event of the past quarter affecting Geology, is doubtless the appearance of the new 'Geological Magazine,' with which is incorporated its predecessor, 'The Geologist.' The last-named periodical, though well supported when it began, had latterly become of a very inferior character, so much so that we have not had occasion to notice it in these Chronicles, and therefore its replacement

* 'Comptes Rendus,' vol. lviii. p. 864.

† 'Comptes Rendus,' Aug. 17, 1864.

by a new and ably-conducted journal is at once a welcome change to the geologist, and an important advance in the science.

The first number of the new journal opens with a brief review of "The Past and Present Aspects of Geology," which contains more "ideal" philosophy than is usually exhibited in the writings of geologists, and sets before the reader, clearly and concisely, a statement of the different phases or "aspects" of the science at the several periods in its history, pointing out and contrasting at the same time "the ideas that during each of those epochs guided the course of geological investigations, forming for the time, so to speak, the rudder of geological thought."

The original articles are all valuable contributions to geological literature. Mr. Salter's paper on "The Pebble-bed at Budleigh Salterton" is an appendix to his description of the fossils from that deposit, which was published in the last number of the 'Quarterly Journal of the Geological Society;' the author comes to the conclusion that these fossils, found in a pebble-bed of the new red sandstone period, belong to the Norman lower Silurian fauna, and are perfectly distinct from English fossils of that age; they therefore indicate the existence of a land barrier between the seas of England and Normandy during the lower Silurian period, a conclusion at which Mr. Godwin-Austen arrived, on independent grounds, some years ago. Mr. Davidson's paper on "Thecidium" is a very exhaustive examination into the value of the recent and tertiary species of the genus, and a description of their anatomy; in the course of which the author shows that many of the so-called species are mere varieties of the recent *Thecidium Mediterraneum.*

The second number quite keeps up the character of the new magazine, and contains two important papers—one by Mr. S. P. Woodward and the other by Mr. Day—besides several others of less general interest. In Mr. S. P. Woodward's paper on "The Bridlington Crag," there is a very complete and useful list of all the species of shells hitherto found in that deposit; and the comparison of this fauna with those of other accumulations, hitherto supposed to be synchronous with it, has led the author to the somewhat unexpected result that the Bridlington deposit can no longer be considered the exact equivalent of the Norwich Crag in age or in climatal conditions, and that the shells "are almost equally distinct from those of the last pre-glacial and those of the first post-glacial deposits, and is (*sic*) much more Arctic than either, as if formed during the climax of the last great age of cold in Britain." Mr. Day's paper on "*Acrodus Anningiæ*, Agass.," treats of the structure of a very remarkable shark, as exemplified by a complete lower jaw found by the author in the lias of Lyme Regis, which apparently contains teeth hitherto referred to two different genera, until now regarded by many eminent palæontologists as belonging to distinct families. Geologists have more frequently to deal with fragments than with perfect specimens, and they therefore often find, as in this case, that structures considered by them, through imperfect knowledge, to be characteristic of distinct genera, or even families, belong in reality to the same individual. Thus the philosophical palæontologist becomes impressed with the consciousness of the imperfection of the geological record; while the man of mere fact—the Gradgrind and Bounderby of palæontology—still clings to his own feeble interpretation of imperfect specimens, and mistaking fancy for fact, adopts as finally true those erroneous notions which the "dreamer" only tolerates provisionally as a plausible hypothesis.

The other articles in these numbers are also interesting; besides which there are several abstracts of foreign memoirs, reviews of recent publications, reports of proceedings of field-clubs, and other matter of interest to the geologist.*

Professor von Ettingshausen has lately published a pamphlet, entitled 'Ueber die Entdeckung des Neuholländischen Charakters der Eocenflora Europa's, und über die Anwendung des Naturselbstdruckes zur Förderung der Botanik und Palæontologie,' and although its immediate object is merely to show that the author was the first to point out the Australian character of the Eocene flora of Europe, and that nature-printing can be used advantageously for the illustration and comparison of recent and fossil plants, yet it advances our knowledge of the subjects treated, by bringing prominently forward the facts essential to his argument; and we freely admit that, after reading his pamphlet, few besides his antagonist, Professor Unger, would be likely to dispute with him either of the points at issue. The advantages attending the employment of the process of nature-printing for purposes of comparison appear so obvious, that Professor Unger's opinion to the contrary is not a little remarkable; and as regards the Australian character of the Eocene plants, Professor Unger's "Dissolving Views" have long made familiar to us his opinion respecting their "insular" character, as distinguished from the inference of Professor von Ettingshausen that they belonged to a "Continental" and New Holland flora.

Dr. Dawson's memoir on 'Air-breathers of the Coal-period,' contains descriptions of all the remains of supposed air-breathers that have been found in the carboniferous strata of Nova Scotia; many of them have been described before by Professor Owen, the author, and others, so that this publication may be considered a synopsis and *résumé* of the whole subject. The vertebrate remains belong to five genera—*Hylonomus*, *Baphetes*, *Dendrerpeton*, *Hylerpeton*, and *Eosaurus*; but the invertebrata are represented only by a *Myriapod* and a *Pupa*, with possibly some insect-remains. The vertebrate fossils were discovered, in the first instance, in the interior of trunks of trees, by Sir Charles Lyell and the author; but the remains of *Eosaurus* (two vertebræ only) have been since discovered by Mr. O. C. Marsh.

Respecting the affinities of the vertebrata—the most important subject treated — it may be briefly stated that Dr. Dawson refers *Baphetes* and *Dendrerpeton* to the Labyrinthodonts, *Hylerpeton* doubtfully to the Archegosaurians, and *Hylonomus* to a new order (*Microsauria*), which he does not define; while to *Eosaurus* he does not assign a place.

* Our limited space compels us to postpone the consideration of the succeeding numbers of 'The Geological Magazine.'

The uncertainty as to the zoological position of the last-named animal has reference only to the order, for it certainly belongs, as do the orders *Labyrinthodontia* and *Archegosauria*, to the class Amphibia (included with the Reptilia by Dr. Dawson); and as regards the new order *Microsauria*, Dr. Dawson states that it "may be regarded as allied, on the one hand, to certain of the humbler lizards, as the gecko or agama, and on the other, to the tailed batrachians." If this be so, *Hylonomus* must have a special interest for the naturalist, as forming a connecting link between two classes of the vertebrata. But the author also states that the genus *Hylerpeton*, though referred by him, with some doubt, to the order *Archegosauria*, "may possibly be a link of connection between the *Microsauria* and the *Archegosauria*."

As these fossils were discovered in association with a mollusk belonging to a genus (*Pupa*) which exists at the present day, and to an order (*Pulmonata*) not otherwise known to occur in beds below the Purbeck, and in the same strata as a myriapod, whose next oldest known representative was found in Jurassic strata, their examination and description naturally led Dr. Dawson to discuss their bearing upon Mr. Darwin's hypothesis of the origin of species. Accordingly the author devotes a chapter to this subject, with which, of course, he has no great sympathy; and we imagine that he refers to this part of his memoir when, in his introduction, he threatens to indulge in gossip without scruple, for we have certainly failed to detect the promised "gossip" anywhere else.

The first part of Professor Owen's "Memoir on the Cavern of Bruniquel and its Organic Contents" was read before the Royal Society on June 9th; it contained descriptions of the human remains found in the cave, and an account of the circumstances under which they were discovered; the contemporaneity of the human remains with those of the extinct and other animals, and the bone and flint implements with which they are associated, being inferred from the similarity of their position and relations in the surrounding breccia, and from the chemical constitution of the human bones corresponding with that of the other animal remains.

Several small portions of human crania were noticed by the author, and more particularly the hinder portion of a cranium, with several other parts of the same skeleton, which were so situated as to indicate that the body had been interred in a crouching posture; also, an almost entire calvarium was described, and then compared with different types of skull, being found to correspond best with the Celtic type. Certain jaws and teeth of individuals were next noticed, especially the lower jaw and teeth of an adult, and upper and lower jaws of children, the latter showing the characters of certain deciduous teeth.

The geological value of this large and unique collection of fossil human remains depends entirely upon its age, and as that can be determined only after a careful examination of the bones associated with them, we must be content to wait patiently for the reading of the second part of this memoir before arriving at a conclusion.

The most complete work that has yet appeared on the geology of Madeira has just been published at Leipzig; it is entitled 'Geologische Beschreibung der Inseln Madeira und Porto Santo,' von G. Hartung; and it contains also descriptions of the fossils by Dr. Karl Mayer. It is the result of several years' investigation of the geology of the island, begun in 1853 in company with Sir Charles Lyell, and since continued by the advice of that distinguished geologist.

Dr. Hartung first describes the different stratified and volcanic rocks composing the islands of Madeira and Porto Santo, the forms of the hills, and the results of marine and sub-aërial erosion, or denudation; but the greater part of the work is taken up with a detailed description of the various peaks, cones, and craters, this part of the subject being well illustrated by lithographed views of the localities, coast-sections of the volcanic cones, and maps of the islands, though the latter are unfortunately not coloured geologically.

Dr. Karl Mayer gives, in the concluding chapter, a full account of the results of his examination of the tertiary fossils of Madeira, and his comparison of them with those from the Azores, and from European localities the strata of which have a well-defined horizon. He differs in some respects from most other palæontologists, and we think he has assigned to the Madeira strata too remote an age in considering them to be of the horizon of Swiss Miocene, for out of 208 species determined by him 72 are recent; and although 91 species (only 9 of which are characteristic) are found in the "Helvetian" formation, yet 80 are found in the "Mayencien" below, and 83 in the "Tortonien" above, the numbers being so nearly alike that the difference may be due to accident, and the percentage of recent forms (35) being far too great for the "Helvetian" strata.

About two years ago geologists were not a little surprised at an announcement made by Dr. H. B. Geinitz, of Dresden, an eminent palæontologist, that he had discovered a Trilobite in the collection of Madame Kablik, from the Rothliegende of Nieder-Stepanitz, near Hohenelbe, which he had therefore named *Dalmanites Kablikæ;* with it was associated another crustacean, to which he gave the name *Kablikia dyadica.* Both fossils occurred in a black micaceous clay-slate, not distinguishable from a similar rock occurring at Nieder-Stepanitz, and therefore Dr. Geinitz felt certain that Madame Kablik was neither deceived nor deceiving when she assured him that it came from that locality. The word of a lady, aided perhaps by her looks, was sufficient to upset Dr. Geinitz's faith in palæontology, its laws and its facts; but other palæontologists, far removed from the personal influence of the fair collector, were sufficiently prosaic to put the veto of their calmer judgments on the validity of the asserted fact. Dr. Geinitz, stimulated by the discovery of a more perfect specimen in the lady's cabinet, set about confounding his compeers; but "facts are stubborn things," and he therefore gradually became convinced that his *Dalmanites Kablikæ* was none other than the *Placoparia Zippei*, Böck, sp.—a species which occurs in the old *Silurian* slates of Dobrotivá, near Beraun! Dr. Geinitz lingers lovingly over his

Dalmanites Kablikæ before consigning it to its grave, and then laments that *Kablikia dyadica* must be "degraded" to *Kablikia silurica!* This result of the "unangenehme Täuschung" is stolidly described in the recently published 'Sitzungsberichte der natur-wissenschaftliche Gesellschaft Isis zu Dresden' for 1863 (p. 50). We give the page because, like the works of Mr. Carlyle's 'Dryasdust,' the "Isis" has no index.

All geologists feel themselves participators in some degree in the honour which has just been conferred by Her Majesty upon Sir Charles Lyell, who has recently been created a baronet of the United Kingdom, under the title of Sir Charles Lyell, Baronet, of Kinnordy, in the county of Forfar; and we feel certain that the general public is equally pleased that this mark of distinction should have been bestowed by the Queen upon a *savant* who has so often and so ably assisted them to a clear and philosophical comprehension of geological phenomena and their causes.

Progress of the Geological Survey of the United Kingdom.

In our last number we gave an outline of the progress of the Ordnance Survey of these islands, and we now propose to supplement that sketch with an account of the origin and progress of that survey, the object of which is to portray on the Ordnance maps the mineral composition of the surface. It will be evident, therefore, that a correct topographical survey must precede, and form the basis of, a correct geological survey. Now it so happened that a few years after the detailed mapping of the Ordnance surveyors had been commenced in the south of England, the value of geological surveys began to be recognized by the Government of this country, as well as by those of several European states. It was felt that if the area occupied by each geological formation, representing, as is generally the case, some special group of minerals, could be accurately depicted, by colouring on maps of sufficient size, we should be able to arrive at an approximate knowledge of the mineral resources of the country. In the case of the coal-fields, such knowledge would be specially valuable, as forming the basis for correct estimates of our coal-resources. But there are other minerals and rocks only second in value to coal, such as the iron-formation of the Oolitic period, the limestones of the carboniferous, and the slates of the Silurian, and it was wisely determined from the commencement that in the national survey all formations alike should receive equal care and attention, and that the maps should be equally reliable as guides for the miner, the agriculturist, or the man of science.

The Geological Survey of Great Britain had its origin in the indomitable perseverance of its first director-general, Sir H. T. De la Beche. This accomplished naturalist, originally brought up for the army, early turned his attention to science, his mind having been probably attracted to geology by his residence at Lyme Regis, where the cliffs of lias afford to the collector such rich treasures of past living forms. His love of geology increased with his years, and seems to have been especially marked by an appreciation of its practical bearings. Having left the army and arranged his private affairs, he commenced with the whole force of his character to elaborate those plans for a national survey, which he lived to see crowned with success. Being firmly convinced of the importance of a geological survey, on the basis of the Ordnance maps, he determined on a plan which involved no little cost of labour and money to himself, in order to bring the subject forcibly before the leading statesmen of the day. He consequently commenced to trace on the Ordnance maps of Cornwall the boundaries of the geological formations, as well as to insert the mineral veins, dykes, and other phenomena; and having drawn up illustrative sections, "he thus took a first step," to quote the words of his successor, Sir R. I. Murchison, "in leading public men to see the good which must result from the extensive application of such a scheme." Having by this means succeeded in inducing the Government of the day to grant a sum for the support of a limited number of assistants, the Geological Survey was established as a branch of the Ordnance. The grant once made has been gradually augmented, so as to allow the employment of a larger staff of surveyors than was at first contemplated, and the whole undertaking, after having been dissociated from the Ordnance, has at length been placed under the Science and Art department of the Committee of Council on Education.

While pursuing his investigations in the mining districts of Cornwall, Sir H. De la Beche became "forcibly impressed" with the conviction that the survey presented an opportunity not likely to recur of illustrating the useful application of geology, and he in consequence represented to Mr. Spring Rice (afterwards Lord Monteagle), then Chancellor of the Exchequer, that a collection should be formed and placed under the office of the Board of Works, comprising specimens of various mineral substances used in the construction of roads, buildings, and public works, as well as minerals, and models of machinery used in mining, the whole to be tabulated and arranged for easy reference, and thus to illustrate at a glance the mineral resources and mining enterprise of the United Kingdom. Government having acquiesced, the Museum in Craig's Court was appropriated for the purpose. Specimens rapidly flowed in, and the small building was speedily filled. A larger structure was urgently needed, and the director having succeeded in convincing Sir Robert Peel that the dignity and interests of the country required that an adequate and appropriate structure should be erected for the exhibition of the mineral treasures with which it abounds, the present Museum of Practical Geology was founded. "Then arose," to use again the language of the present director-general, "and very much after the design of Sir H. De la Beche himself, that well-adapted edifice in Jermyn Street, which, to the imperishable credit of its founders, stands forth as the first palace ever raised from the ground in Britain which is entirely devoted to the advancement of science." Indeed, when we recollect that the value of the minerals raised in the United Kingdom amounted for the year 1851 to 24,000,000*l.*, it will be admitted that the time had arrived for the erection of a building in some degree proportionate to the position occupied by this country in mining enterprise.

The next step was the establishment of a school of mines. Although in 1851 the mineral produce of this country was calculated at four-ninths of that derived from all Europe, no school having for its object the instruction of persons engaged in mining operations had been established up to that year in the United Kingdom. In this respect other countries had been in advance of ours. France, Russia, Prussia, Saxony, Austria, Spain, Sweden, Denmark, and others even less connected with mining industry, were furnished with schools of mining by their respective governments. The consequence was, that in the theoretical branches of mining we were often far behind. In many quarters there existed a prejudice against the application of science to mining, as though theory and practice were necessarily opposed to each other; and young men who wished to acquire the former as well as the latter, were obliged to go to the schools at Freiburg and elsewhere, in order to be instructed in the rudiments of their profession. A committee of the House of Lords at length reported (1849) in favour of the establishment of a Government school of mines, and the Museum of Practical Geology was fixed upon as the proper centre for its operations. The inauguration took place in 1851, and along with the Geological Survey, the school was placed under the direction of Sir H. De la Beche. The edifice was thus complete in all its details, but he who was the master-builder did not long survive to see the fruits of his labours. A premature decay of his physical powers set in, and he died in 1858, regretted alike by the scientific world and by his own immediate friends, and leaving the department over which he presided to the care of its present director-general, Sir R. I. Murchison.

The progress of the Geological Survey has been, on the whole, from the south and west of England towards the north and east, or from the older to the newer formations. The first maps completed were those of Cornwall and Devon; these in all probability will require a fresh survey, owing to the advance of the science of geology within the last quarter of a century, and the greater attention to minutiæ which has been introduced into the works of the survey, as evinced by the tracing of several subdivisions in the New Red Sandstone and Millstone grit formations of the central counties. In South Wales the Survey had the advantage of the labours of Sir William Logan, now director of the Geological Survey of Canada, who had, previous to the year 1840, collected a vast amount of information relating to the South Wales coal-field, which, together with the maps and sections he had constructed, he placed at the disposal of the director-general. This vast tract of Carboniferous rocks, embracing portions of several counties, rising into lofty table-lands, and penetrated by valleys of unusual depth, is one of the marvels of our country. Having an area of 900 square miles, and with seams of coal descending to depths of several thousand feet, there can be no doubt regarding the almost unbounded resources of its minerals, which well deserve all the labour that may be required for their elucidation. Professor Ramsay, in his inaugural address at the School of Mines in 1857, states that after the publication of the maps of that country, landowners, colliery proprietors, coal viewers, and mining engineers all acknowledged their importance, and that a gentleman well versed in mining and scientific geology observed to him, "that the publication of the Government maps had placed them" (the colliery proprietors of South Wales) "thirty years in advance of what they were before."

The disentanglement of the geological intricacies of North Wales was a work requiring a more than ordinary amount of skill and perseverance. In many places the slaty rocks and grits are repeatedly broken by faults, traversed by dykes of igneous rocks, or metamorphosed by enormous protrusions of trap, or old sub-marine lava-flows. To trace out on the small one-inch maps of the Ordnance Survey each particular dyke, band of slate, or bed of limestone, amongst wild tracts of moorland or precipitous ranges of mountains, with few objects to guide the surveyor in determining his position, and often obliged to carry on his work amidst seething mists or pitiless storms, at other times puzzled to determine the very nature of a rock in regions where the characters and aspects of the formations are as changeable as the colour of the sky overhead, and when the whole structure of the beds is suddenly disarranged and thrown into disorder by the occurrence of a fault or dyke,—out of all this chaos to evoke order and system, and in spite of all obstacles to produce the geological maps which are now in the hands of the public,—was a work which we venture to think has never yet been fully appreciated except by the very few field-geologists who have made attempts at similar undertakings. It cannot, however, be otherwise than gratifying to those gentlemen who have been engaged in the survey of this and other parts of the kingdom, to find one of the most influential newspapers in the North of England recognizing the merits of the survey in a leading article, in such language as the following:—"The manner in which this geological picture of the kingdom has been executed, commands the admiration of all competent judges. At the Paris Exhibition of 1855, the map, as far as it was then completed, was admitted by the geologists and miners from all parts of Europe who flocked thither, to be the finest work of the kind yet achieved, and elicited general praise for its detailed truth and precision in the delineation of those dislocations of the crust of the earth, the tracing out of which is so laborious, and can be accomplished only by men of profound science."*

The survey of the Midland and Western counties of England has been completed, embracing several of the most important coal-fields, and those tracts of the newer formations under which the coal is considered to be hid, and which may be regarded as reserves of mineral fuel kept in store for the use of future generations. It is hoped that the labours of the survey will throw light on the question of the position and depth of the beds of coal under the Triassic and Permian

* 'Manchester Guardian,' 27th July, 1864.

formations over considerable areas. Of the most important coal-fields, those already completed are the following:—North and South Wales, Bristol and Somersetshire, Forest of Dean, Forest of Wyre, Coalbrook Dale, North and South Staffordshire, South Lancashire (on the 1-inch and 6-inch scales), Warwickshire, Leicestershire, Derbyshire, and part of Yorkshire. In Scotland the coal-fields of the Lothians and Fifeshire have been published on the two scales above mentioned; and in Ireland several of the coal tracts, economically of small importance, have also been examined.

The importance of completing the survey of the country surrounding the metropolis has for the last few years been steadily kept in view, so that the "London basin" has been completely enclosed, together with the rich district of the Weald of Kent to the south of it. As the Chalk and Greensand formations may be regarded as reservoirs of water, which are even now very largely drawn upon by the Artesian wells of the city, the accurate delineation of the extent of these water-bearing formations possesses more than a mere scientific interest.

Having completed that part of England which may be described as lying to the west of the line of the Great Northern Railway, and south of the valley of the Thames, the course of the survey would, under ordinary circumstances, have extended into the purest agricultural district of the Eastern counties. Here the geological maps could have possessed little or no economic value. This being so, it has been represented very forcibly to the director-general (as we learn from the report for 1863) that there would be greater practical utility in employing the staff of surveyors on the remaining Northern counties, so rich in their stores of coal, iron, and other minerals of the Palæozoic age, while the Eastern counties, formed of drift-covered strata of the Secondary and Tertiary periods, might be allowed to wait till after the completion of the former. Sir Roderick Murchison states that he has recognized the force of these representations, so that we may expect the six Northern counties, with their important coal-fields, will in the course of a few years be geologically portrayed on the Ordnance maps.

An important branch of the Geological Survey is the preparation of vertical and horizontal sections; the former for the purpose of showing in columns, on a scale of 40 feet to an inch, the vertical succession of the strata; the latter to illustrate the geological structure of a particular line of country, down to a natural scale of 6 inches to a mile, and with a datum of the sea-level, or a thousand feet below. The horizontal sections are all actually levelled, and represent in outline the *natural* features of the country; not the distorted undulations of a railway section. In these sections the outcrops of the coal-seams, the boundaries of the formations, and the faults are shown in their true places as far as can be determined, and thus we obtain a representation of the interior of the earth as it would appear if laid open along this line down to the level of the sea, or lower. In Wales and other districts, the sections have been carried across the highest mountains, and give a faithful outline of the surface along definite tracts of country or across precipitous descents, where the most adventurous climber seldom dares to tread.

The immediate direction of the field-work of the British survey is in the hands of Professor Ramsay, F.R.S., to whose close attention to accuracy of detail, combined with a profound acquaintance with physical geology, the trustworthy character of the maps and sections is greatly due. The Irish survey, under the able management of Mr. Jukes, F.R.S., is also making rapid progress. During the past year 1,453 square miles were surveyed in Great Britain, and 818 square miles in Ireland, portions of these being re-surveys of the superficial drift accumulations.

Complaints have sometimes been made, and with some show of justice, of the slow progress of the British surveys. This has been mainly owing to two causes. In the first place, for several years after the survey had been set on foot, under Sir H. De la Beche, a very small number of surveyors, not exceeding half-a-dozen, was allowed by the Government to be employed at one time. In the course of time the staff was gradually increased, and this source of delay may now be said to have been surmounted. The second cause is still in existence, namely, the low scale of remuneration granted by Government to the surveyors. We have no hesitation in saying this is short-sighted policy, and will eventually result in a larger outlay of the public funds. The result, as proved in many cases, is that the young surveyor, as soon as he has passed through a couple of years or so of training in the field, which is in every case necessary, and is ready to commence operations on his own resources, is tempted to accept the first offer of a surveyorship in the colonies, or any other opening that presents the prospects of a competency. Thus the public lose the benefit of his services soon after he has become capable of rendering them. Under the present scale of remuneration this branch of the public service (in common with another connected with the same department of the state, namely, the "Science Teacher") can only be regarded as a stepping-stone to some more substantial source of livelihood, as it is scarcely possible the Surveyor can save out of his income, or that his physical strength will withstand the wear and tear to which he is exposed till the age at which he is entitled to retire on a pension.

VI. MICROSCOPY.

The history of embryological science dates from the invention of the microscope, and has advanced *pari passu* with the improvements of that instrument and the facilities afforded to microscopical observers.

Dr. C. Robin has lately directed his attention to the development of the spinal column from its earliest stages with some important results. He has succeeded in showing that the atlas and axis vertebræ offer this peculiarity, that the first constitutes a vertebral ring without a body, whilst the second has two vertebral bodies united in one. The odontoid apophysis, in fact, is nothing more nor less than the body of the atlas, which during the processes of development becomes thus separated from its proper connection, and gives rise to that wonderful piece of mechanism met with in the cervical region of the mammalian class. When the mammalian embryo is from four to six millimetres in length, the observations are commenced. The guinea-pig, rabbit, rat, dog, sheep, pig, cow, and human fœtus have all been submitted to examination by the author. At the early period when the embryo has this size, the cartilages of the first three or four thoracic vertebræ may be observed situated near the middle of the notochord. They increase rapidly in number, both in the anterior and posterior directions, until the number of twenty-four is attained; the sacral and coccygean bodies appear later. The vertebral bodies are separated from one another by regular spaces or intervals, traversed by the notochord. This, after a time, dilates in these interposed spaces and becomes fusiform, afterwards becoming flaccid and surrounded by a viscid fluid, thus giving rise to the intervertebral tissue. Although the vertebral cartilages are the first to appear in the body, yet the cartilage of the axis does not appear in the guinea-pig until it has attained a length of eleven millimetres. This cartilage originates in two distinct pieces, the anterior of which evidently belongs to the atlas. They unite to form the single body of the axis vertebra before ossification has commenced and whilst yet in a purely-cartilaginous condition. In the human fœtus the union takes place when the length is about fourteen millimetres. The ossification of the two vertebræ and the anomalies observed in various species of Mammalia are treated of at some length by M. Robin. His decision as to the nature of odontoid process is beyond controversy, and has established a fact for many years denied by some physiologists.

M. Pouchet has lately published some observations connected with spontaneous fission in Infusoria. He considers this a much rarer phenomenon than is usually affirmed; and with regard to the *Verticellæ*, states that during twenty years' observation he has failed to detect a single instance of fissiparity in these animalcules. A monstrosity with two bells on a single stalk has been often mistaken for the commencement of fission; whilst it frequently occurs that a free verticellid attaches itself to the bell-shaped body of a fixed individual, and is another source of error.

M. Elias Mecznikow has described, in Du Bois-Raymond's 'Archiv.,' a new form of the genus *Sphærophrya*, the connection of this acinetiform animalcule with the Paramæcia being illustrated by a series of very beautiful drawings.

Professor Gulliver continues his interesting researches on Raphides. Should he be enabled to extend his researches sufficiently, a very important test would be afforded to the analytical microscopist, as regards the adulteration of vegetable articles of commerce.

M. N. Lieberkuhn has published some interesting observations on the changes occurring in Sponges after death. It appears that in the species he observed, the whole sponge does not die, but parts fall away and decay; other portions emit prolongations, which become detached and remain at the bottom of the vessel in which they are kept. When observed under the microscope, they are seen to be provided with vibratile cilia, and contain siliceous spicules; some portions emit processes similar to those of Actinophrys, others become encysted. From the cysts from four to five monads emerge, provided with a single whip, and capable of swimming or performing amœbiform movements. Similar monads have been observed in the eggs of other low forms of invertebrates.

Researches conducted with the aid of the microscope will doubtless explain many strange phenomena, and place many facts within our comprehension which, before, were veiled in mystery. The discovery of fatty degeneration of the heart and liver has accounted for sudden deaths, which are of frequent occurrence, and where no diseased condition of body is perceptible to the unassisted eye. It appears, however, from the researches of M. Tigri, recently published in the 'Comptes Rendus,' that this disease extends to the blood itself. A fatty substance has been found to accumulate in the red blood-corpuscles which materially influences the circulation, and in the opinion of the author frequently produces death.

Dr. T. F. Weisse, of St. Petersburg, gives a detailed account of the development of the eggs of *Floscularia ornata*, in the last number of Kölliker's 'Zeitschrift.' Whilst the author was engaged in investigating the eggs of the Rotifera, he discovered a beautiful example of *Floscularia ornata* in his aquarium, which had already deposited four ova; a fifth was afterwards expelled from the animal under observation by forcible contraction of the body. The germinal vesicle was still observable in this last ovum. No remarkable change took place in the ova for two days, until in one a bright red spot was observed, and on the following day two distinct eyes, which moved with the already-visible embryo; other changes were observed in the course of the day; ciliary motion appeared near one end of the embryo, and the pharynx exhibited movements at times. At the end of five days, the ovum was ruptured and the little animal issued from its shell, using a worm-like movement and showing clearly the circle of cilia at its anterior extremity. A figure is given of the embryo at this period, when it bears not the least resemblance to the parent, and would easily be considered as a distinct species of animal. The development appears to take a considerably longer period than was generally supposed to obtain among the Rotifera. M. Weisse believes seven days to be the period passed by this species in the ovum after emission from the parent's body.

The application of photography to the delineation of objects beneath the microscope does not advance in that rapid manner, or receive the amount of attention, which is to be desired. There can be no surer method of settling many disputed points of structural anatomy than the circulation of well-executed photographs of the objects under discussion. M. Duchenne, of Boulogne, has succeeded in obtaining some very accurate photographs of the microscopic appearances of the spinal chord of the human subject. The magnifying power used in obtaining these photographs was from 200 to 1,000 diameters.

Dr. Clark, of Harvard University, has described the eggs of *Tubularia*, in 'Silliman's Journal,' vol. xxxvii. His observations have led to some very interesting results. The eggs of *Tubularia* have hitherto escaped the attention of naturalists. Dr. Clark accounts for this by the extreme minuteness of the ova, which he was unable to detect with a power less than the ¼-inch.

VII. MINING, MINERALOGY, AND METALLURGY.

Mining.

For some years past there have issued from the 'Mining Record Office,' one of the Departments connected with the Museum of Practical Geology, very complete returns of the value of our mineral productions. From these "mineral statistics" we learn the total value of our mineral produce in 1863 to have been 29,151,976*l.*, which, when brought into the metallic state, at the actual cost of manufacture, was increased to 36,364,327*l.** The more important minerals were the following:—

	Tons.	Value at place of production.
Coal	86,292,215	£20,572,945
Iron ore . . .	9,101,552	3,240,890
Tin	15,157	963,985
Copper . . .	210,947	1,100,554
Lead . . .	91,283	1,193,530

The quantities and values of the metals obtained from these being:—

	Tons.	Value.
Iron, Pig . . .	4,510,040	£11,275,100
Tin . . .	10,006	1,170,702
Copper . . .	14,247	1,409,608
Lead . . .	68,220	1,418,985
Silver obtained from the lead .	ounces 634,004	174,351

In addition to the above, returns are given of zinc, sulphur ores, wolfram, arsenic, and other minerals, showing in detail, the actual value of every mining district in the United Kingdom.

By the issue of these annual statistics, and by preserving records of all our subterranean operations, the Mining Record Office is rendering important service to all our miners and manufacturers.

The production of gold from the quartz lodes of the Cambrian mountains shows a considerable falling off during 1863, the total produce for the year being 552 oz. 12 dwts. and 19 gr. only. The prospects, this year, are however much more promising. The following is a return made on the 13th August:—At Castell Carn Dochan 5 oz. and 12 dwts. of gold were obtained from 20 cwt. of quartz from the lode and alluvial matter; this makes a total of about 50 ounces obtained from that mine during this year. At the Welsh gold mine it

* 'Mineral Statistics of the United Kingdom of Great Britain and Ireland' for the year 1863, with an Appendix. By Robert Hunt, F.R.S. Published by order of the Lords Commissioners of Her Majesty's Treasury.

is said that 66 ounces of gold were obtained from 44 cwt. of quartz; and about two cubic yards gave 7 lbs. of gold. At the Prince of Wales a new discovery is stated to have been made; and at the old Clogau copper mine the quartz yields about 1 oz. of gold to the ton.*

The reports of the Government Inspectors of Collieries for 1863 have been published. They are satisfactory as compared with the previous year, which was unusually disastrous, and also as compared with 1861. The following tabulated summary of the deaths of colliers will place the number and character of the accidents at once before the reader:—

	1862.	1863.
Explosions of fire-damp	190	163
Falls of roof and coal, &c.	422	407
In shafts	137	147
Miscellaneous accidents under-ground and at surface	384	190

This last return—for 1862—includes the number sacrificed by the Hartley casualty, by which 204 men were lost. The total deaths in collieries in 1862 was 1,133, the deaths in 1863 being 907, or 226 less.

It is admitted, on all sides, that the only method promising to improve permanently the condition of our mining population, and by improving the miner to lessen the number of accidents in working our mines and collieries, is to be sought in an improved education. Miners at present, for the most part, are entirely uninstructed in any of the principles involved in their labours. They are expected to use the precautions which science tells us should be employed, and yet we make no effort to teach them what those precautions are, or on what principles they depend. A safety lamp is placed in the hands of a collier without his knowing one of the conditions which makes it a *safety* lamp. Yet the moment an ignorant man tampers with the wire gauze he is punished. Surely this is not consistent with reason or justice. It is to be regretted that one of the most promising experiments towards educating the working miner is abandoned. The Glasgow School of Mines is shut up, subscriptions from the coal and iron masters of that wealthy district having entirely failed. We fear the British Mining School cannot be long continued; and the Miners' Association of Cornwall and Devonshire does not appear to be in a healthful state. Surely, in a country producing minerals to the value of nearly thirty millions sterling, there should be found establishments in which so much of science as can be directly applied by the miner with advantage to his labours, might be obtained at small cost, and with but little sacrifice of time. The Royal School of Mines, as a central establishment, is all that can be desired; but local schools in connection with it should be at once established.

The application of machines to the cutting of coal appears to be becoming general. Several new patents have been obtained. One by Mr. Harrison, of Tudhoe Iron Works, is well spoken of, but we have

* 'Mining Journal,' August 13, 1864.

not yet been made acquainted with any practical results which will admit of our comparing it with those which we have already described.

Much attention has recently been given to mining-powder, with a view to increase its disruptive power, and produce it at a cheaper rate. M. Nobel states that by damping mining powder with nitroglycerine its explosive power is trebled, and the noise of the explosion much less than when ordinary powder is used. One firm is making blasting-powder with nitrate of soda instead of nitrate of potash, by which the cost is reduced one-third, but this powder has the objection of a tendency to deliquescence unless it is very carefully kept. In another powder, the spent tan of the tanners' yards is substituted for charcoal, and an increased activity given to the composition by the addition of a little chlorate of potassium. This explosive powder is said to have a considerable amount of disruptive power; in price it stands about equal to that manufactured with nitrate of soda.

A composition for mining purposes is now being subjected to experimental trial in some of the mines near Tavistock, in Devonshire. The peculiarity of this is, that the materials which constitute it are kept apart, or at least in two parcels, neither of which are in themselves explosive. They become so, however, on being mixed in certain defined proportions, which is not done until the moment of its being placed in the holes. The actual composition of this explosive agent is not stated, but it must of necessity consist of carbonaceous matter in one parcel, and of some agent which rapidly developes oxygen—as nitre or chlorate of potassium — in the other. At the request of Lord Kinnaird, the chairman of the Mines Commission, a series of experiments has been made in Dolcoath and some other mines with gun-cotton, as manufactured by the Austrian process. The results were satisfactory as regarded its explosive power and the absence of *visible* smoke. Dr. Angus Smith and Dr. Bernays are engaged in the analysis of the air collected in the mines before and after the explosions. The report of the Commission will contain these analyses, and much special information on the use of gun-cotton in mines. Mr. John Scott Russell's paper on "Gun-cotton," in the last number of 'The Journal of Science,' contains all the most recent information on this explosive compound.

Mineralogy.

W. C. Bischoff* has shown that the basic silicates of alumina are more refractory than the acid silicates. Alumina artificially obtained and chemically pure, is less refractory than chemically pure silica; but natural alumina is more refractory than natural silica as found in quartz rock-crystal and amethyst. Herr Bischoff has also discovered that the mineral pyrolusite may probably be found to be a new source of the rare metal *thallium*, a specimen in his collection giving 1 per cent. of this new element.

H. Haidinger has communicated† to the Académie Impériale des

* 'Journal d'Erdmann et Werther.' 'Annales de Chimie.'
† 'Ann. der Chem. und Pharm,' vol. cxxix. p. 375.

Sciences de Vienne his continued researches on "Metallic Irons which are probably non-Meteoric." This examination is of the utmost importance, as tending to the settlement of a vexed question. We have no doubt but many of the masses of "meteoric iron" so called, to which attention has been directed, will be found to be of terrestrial origin. We reserve, until the inquiry is yet further advanced, any extended notice of these investigations. It is sufficient to state, at present, that MM. Haidinger and Hornes consider that they have proofs that many of the specimens in the Imperial Museum of Vienna are not of meteoric origin. There can be no doubt but that many of the masses of iron reputed to be meteoric are so in reality; indeed, we appear to possess good evidence of the actual observation of their fall. It is, however, a question deserving serious inquiry, whether every mass of native iron containing manganese, cobalt, and nickel is of atmospheric origin.

M. Cloëz and M. Pisani Lowe both instituted a very careful analysis of the aërolithe of Orgueil. In many respects this meteoric stone is found to resemble the mineral Serpentine, analysis giving the following constitution:—Silica 26·08, magnesia 17·00, protoxide of iron 21·60, lime 1·85, soda 2·26, potash 0·19, oxide of manganese 0·36, alumina 0·90, chromate of iron 0·49, oxide of nickel (with cobalt) 2·26, sulphuric acid 1·54, hyposulphuric acid 0·53, chlorine 0·08, sulphur 5·75.*

In connection with the inquiry on meteoric stones, M. Haidinger and others have investigated all the conditions under which graphite occurs in nature.

A report has been published,† from which we make a few extracts:—

"One word on the formation, still so little known, of graphite (plumbago, pencil lead). The presence of graphite in granite, gneiss, and diorite has renewed the disputes between the Neptunists and Plutonists. Graphite is well known to be nearly pure carbon, for it leaves in burning but a very small quantity of ash. Now, if these primitive crystalline rocks are of igneous formation, it is impossible to explain how graphite could co-exist with silicates of protoxide of iron without having reduced these salts. Judging merely by what takes place in blast furnaces, carbon reduces all oxides of iron at a high temperature. It must then be admitted that granite, gneiss, and diorite did not contain graphite when the mineral elements of these rocks, such as mica, hornblende, and other ferrous silicates, were in a state of fusion. Graphite then must have been subsequently introduced into these rocks, but when, and how? Questions such as these are very difficult to answer satisfactorily. The most plausible hypothesis is that graphite has been introduced by the wet way into the crystalline rocks and substituted for one of the mineral components. Thus in the gneiss of Nassau (Bavaria) it takes the place of mica.

"Graphite is frequently to be met with in granulated limestone, a fact particularly interesting to geologists. Is limestone a product of eruption, or is it a sediment transformed by the action of heat? The presence of graphite is explicable by neither hypothesis. For at a certain temperature, which need not be very high, carbon decomposes carbonate of lime.

* 'L'Institut,' August 10, 1864.

† See 'Cosmos,' pp. 720, 725, 1864, and 'The Chemical News,' August 6, 1864.

This salt may, no doubt, under strong pressure be heated to the melting point without losing its carbonic acid; this is a laboratory experiment often cited by the Plutonists; but it is quite a different thing with a mixture of carbon and carbonate of lime at a high temperature. If we reject the Neptunian origin of granulated limestone, we must then, as with crystalline rocks, suppose that graphite has been introduced by the wet way at a more recent period. The same remark applies to magnetic pyrites (sulphide of iron) often very rich in plumbago kerns. Does graphite, like all carbon, belong to the organic kingdom? It is certain that anthracite, lignite, coal, are the result of the slow decomposition of an enormous quantity of vegetables. The impressions found on them often indicate the kind of vegetables, most of them extinct, which have contributed to these carbonaceous formations. Graphite, if not formed in precisely the same way as coal and anthracite, nevertheless bears signs of an organic origin. The formation of nuclei and veins of graphite in crystalline rocks is sufficiently explained by the decomposition of carbonized hydrogen gas at a high temperature; this gas, disengaged from organic matters, and penetrating the fissures of the burning rock, would undergo decomposition into hydrogen and carbon.

"It is this deposited carbon which forms graphite. If in our laboratories we do not obtain exactly the same product, it must be remembered that nature has means at her command which escape our researches. We find it impossible to make coal from wood. The wood may be carbonized by the dry or by the wet way. In the first case the carbonization is very rapid; in the latter it is extremely slow, as is shown by the blackened points of piling sunk in water. Finally, graphite has been found in meteorites or aërolites. Attempts have been made to explain its presence here by the continuance of these stones in soil more or less rich in carbonized principles. But with regard to newly-fallen stones, this explanation is inadmissible. If it be maintained that graphite is an organic product, it must be admitted that in the case of newly-fallen meteorites it can proceed only from organic matters belonging to another world than our own."

A very interesting account of the mode of occurrence of the emeralds of Salsburg has been lately communicated to the Imperial Institute of Geology at Vienna, by M. Lipold. These emeralds are found in the valley of Habach, in the district of Haut-Pinzgau. The locality in which they are discovered is 2.212 metres (of rather more than 39 inches) above the level of the Adriatic. These emeralds are cemented in a mica schist which is regularly bedded in the great system of the crystalline schists of the central Alps, passing on one side into a talcose schist, and on the other to a very fine grained gneiss, rich in mica. In each of those the emeralds are found inclosed. The bed of emeralds has been opened upon for the length of 227 metres, with a thickness of from 2 to 4 metres. These emeralds have usually the form of prisms with six faces, and are either of a deep dark-green, or of an apple-green colour. Stones of a fine green colour and free from flaws are rare. The largest which have yet been found have been about 13 centimetres (the English inch is about $2\frac{1}{2}$ centimetres) in thickness and 52 centimetres in length.

M. Henri Ste. Claire Deville communicated to the Académie des Sciences a note from M. Wœhler, in which he relates some experiments which appear to show that M. Lewy was not quite correct in stating that the colour of the emerald was due to organic matter. M. Lewy was led to believe that this was the case, as the gem appeared to lose colour on the application of heat. M. Wœhler does not find this to be the case; and he imparts a similar colour to glass by the use of chromic oxide, from which he concludes that this is the colouring agent, though he does not deny the presence of some organic matter.*

Mr. H. C. Sorby, F.R.S., who has associated his name with the microscopic examination of rocks, has communicated to the Royal Society a continuation of his inquiry as directed to the structure of meteorites.† Mr. Sorby says:—

"In the first place it is important to remark, that the olivine of meteorites contains most excellent 'glass-cavities,' similar to those in the olivine of lavas, thus proving that the material was at one time in a state of igneous fusion. The olivine also contains 'gas-cavities' like those so common in volcanic minerals, thus indicating the presence of some gas or vapour." . . . "Some isolated portions of meteorite have also a structure very similar to that of stony lavas, where the shape and mutual relations of the crystals to each other prove that they were formed *in situ* on solidification." . . . "In others the constituent fragments have all the characters of broken fragments. This sometimes gives rise to a structure remarkably like that of consolidated volcanic ashes, so much, indeed, that I have specimens which, at first sight, might readily be mistaken for sections of meteorites. It would therefore appear that, after the materials of the meteorites are melted, a considerable portion was broken up into small fragments, subsequently collected together, and more or less consolidated by mechanical and chemical actions, amongst which must be classed a segregation of iron, either in the metallic state or in combination with other substances. Apparently this breaking up occurred in some cases when the melted matter had become crystalline, but in others the forms of the particles lead me to conclude that it was broken up into detached globules while still melted. This seems to have been the origin of some of the round grains met with in meteorites; for they occasionally still contain a considerable amount of glass, and the crystals which have been formed in it are arranged in groups radiating from one or more points on the external surface, in such a manner as to indicate that they were developed after the fragments had acquired their present spheroidal shape." . . . "There are thus certain peculiarities in physical structure which connect meteorites with volcanic rocks, and at the same time others in which they differ most characteristically."

Mr. Sorby promises a continuation of this interesting subject.

A correspondent of 'Les Mondes,'‡ from Palermo, reports the discovery, near Nicosia, in the province of Catania, of a quicksilver mine. The mineral is said to exist in great abundance.

At a recent meeting of the Académie des Sciences de Paris, M. Ste. Claire Deville presented an analysis made by M. Damour of a new and very rare mineral, to which they have given the name of *Parysite.* This mineral contains 3 equivalents of carbonic acid, 2 equivalents of oxide of cerium, 2 equivalents of oxide of lanthanium

* 'Comptes Rendus,' June 27, 1864.
† 'Philosophical Magazine,' August, 1864, p. 157.
‡ 'Les Mondes,' June, 1864.

and of didymium mixed with chloride of calcium. Its density is 4·358, and its hardness intermediate between apatite and fluor-spar.

The same industrious and intelligent chemist, whose studies in mineral chemistry are of the highest character, has communicated to the Academy some remarks on the isomorphism of arsenic and antimony. This note by Ste. Claire Deville has been elicited by the remarks made at the sittings of the Academy of Sciences in June and July. We must refer all who are interested in these mysterious actions of crystallogenic force to the papers themselves, which will be found in the 'Annalen der Chemie' and in 'L'Institut.'

Mr. T. Sterry Hunt continues his "Contributions to Lithology." He examines, first, some eruptive rocks, such as quartziferous porphyries, trachytes, &c.; he then proceeds to describe the conditions under which orthoclase porphyry and syenite occur. In these papers we have a very complete geological investigation of the subject, and a careful physical examination.*

The new metal *Indium*, so called on account of the indigo-blue line which it shows under spectroscopic examination, has been found by Reich in the black blende ore of Himmelfahrt mine, near Freiberg. Two hundred pounds of this blende (the black jack of our miners) yielded a few grammes of the new element.†

We noticed in our last a new Cornish mineral, which Professor N. S. Maskelyne had described. He has since that period exhibited this mineral at a recent meeting of the Geological Society. He proposes to call the mineral *Langite*, in honour of Professor Victor von Lang, of the University of Gratz, and formerly of the department of Mineralogy in the British Museum.

Quicksilver has been discovered in New Zealand. A correspondent of 'The Argus' (colonial paper) states that over an extensive tract on the slope of a hill, at the depth of about 5 feet, this metal is found mixed with the "wash-dirt," which is about 9 feet in depth. The gold which has been discovered in the same locality is all in the state of amalgam.

Metallurgy.

The high price of bismuth, and the scarcity of the ores of that metal, have led M. Balard to make experiments on worn-out type metal with a view to its recovery. This French chemist has been to some extent successful. By solution in nitric acid, nitrates of lead and bismuth are obtained. After rendering the solution as neutral as possible, plates of lead are placed in it, when bismuth is precipitated in a metallic state. The tin is recovered by reduction on charcoal; and the lead, as a carbonate, by precipitation with carbonate of soda.

The extraordinary price attained by this metal was due to a circumstance which would scarcely be suspected in the present day. A company was formed in London, under the direction of a foreigner,

* 'The American Journal of Science and Arts,' conducted by Professors Sillimans and Dana, July, 1864.

† 'Berg. u. Hüttenmännische Zeitung,' vol. xxiii., 1842.

for the purpose of *making gold.* Very large premises were taken, and much apparatus placed in position to carry out the most recent attempt at transmutation. Bismuth was to have entered largely into the process, and all that could be obtained was purchased by the company regardless of price. Of course, no gold has been made, and to save, out of the wreck, as much as possible, the deluded shareholders are cautiously selling their stock of bismuth, so as to obtain as high a price as possible, and thus by a legitimate process convert it into gold. Few things can show more strikingly than this does the deficiency of knowledge amongst a large and respectable class of people. It was not long since that the writer of this notice was positively told by some gentlemen, that they were about to extract aluminium from quartz, and if embarking a large sum of money in so wild a scheme may be regarded as a proof of their conviction that this was possible, that proof certainly existed. Still more recently a man supposed to be an experienced miner has returned from abroad, bringing with him what he regarded as very fine specimens of tin, whereas they are only crystals of wolfram (*tungstate of iron*), and consequently valueless. Such instances surely show the necessity of making some of the sciences part of our ordinary educational system.

It has always been a complaint that there is a considerable loss of silver in the reduction of that precious metal from the rich ores of the Mexican mines. M. Poumarède has turned his attention to this, and in a communication to the Paris Academy of Sciences he states his belief that this is due to an imperfect chloridization of the silver, and consequently irregularity of action. He states that if finely-powdered quartz be mixed with about 1 per cent. of silver powder and 2 or 3 per cent. of salt, and heated for half-an-hour to redness in a covered crucible, all the silver will be found to have passed into the form of chloride, soluble in ammonia. If the silver is in the form of sulphide, or any other compound, the same result is obtained. When, instead of quartz, we use felspar,—either with or without earthy carbonates, oxide of iron, or other constituents of the veinstone,—the same conversion into chloride takes places in an equally complete manner. The application of this in the processes of reducing silver ores is obvious.

Attention is again being directed to the combination of tungsten with steel. Some years since Mr. R. Oxland patented a process for separating wolfram (tungstate of iron) from tin, and it was proposed to employ the tungstate of soda obtained in the process as a mordant, and the metallic tungsten as an alloy with iron. M. Jacob subsequently made steel, with tungsten in its composition, and carried out some large and apparently satisfactory experiments at Sheffield and in Austria. The results were so promising that M. Jacob gained possession of nearly all the sources of wolfram in this country. For several years, however, nothing has been heard of this alloy.

Now M. Le Guen has solicited attention to what he calls *wolframed pig-iron.* Experiments have been made at Brest, and the pig tested was found to offer a greatly-increased resistance when less than 2 per cent. of wolfram had been added to the iron. Another description of pig-iron, formed of one-third of best old English pig and two-thirds of the fragments of old cannon with German wolfram mixed in the same proportion, show an augmentation of resistance equal to about sixty-eight kilogrammes per square centimetre.* Numerous other experiments of a similar character were made, the results appearing to be, in all cases favourable to the wolframed pig-iron. There is much difference in the character of the tungstate of iron. The French wolfram, containing a little arsenic and sulphur, is not equal even after roasting to the German mineral, which is very pure.

We noticed in our last Journal Mr. Griffiths's mechanical puddler. Another patent has been obtained by Mr. Thomas Harrison, of the Tudhoe Iron Works, Ferry Hill, Durham, for "improvements in machinery for puddling iron and steel." We are not yet aware of any works at which this new arrangement has been adopted. The moment we learn the result of any trials we will communicate the same to our readers.

VIII. PHYSICS.

Light.—It might be imagined that such an obvious question as that of the relative brilliancy of various portions of the solar disc would have been definitely settled by this time; yet we find physicists still adhering to the opinion that both the centre and the circumference are equally luminous; whilst others, by far the larger majority, adduce experiments and reasonings to prove that the centre is considerably more luminous than the marginal portions of the disc. Respecting the actual *light* which comes from the sun, we are not aware that any accurate photometric experiments have yet been made, although observers have long noticed a difference in luminosity between the centre and the edge; but we find that the variations of chemical and thermic, follow so completely those of luminous intensity, that it will be admitted that what is proved of the two former holds equally good in the case of the latter. Secchi† has shown that the calorific radiation of the centre of the sun's disc is nearly double that from its borders, and that the equatorial regions are somewhat hotter than the polar. More recently, Roscoe,‡ in some carefully-conducted experiments, showed that the intensity of the chemically-active rays at the centre was from three to five times as great as that at the edge of the disc, and that the chemical brightness of the south polar regions was considerably greater than that of the north polar regions, whilst about the equator the brightness was between that of the poles. Professor Roscoe's results were obtained by exposing a prepared paper in a camera to the action of the sun's image, and comparing the shade of tint produced thereby at the centre and at the circumference with a

* A kilogramme is the fiftieth part of an English cwt., and a centimetre about four-tenths of an English inch.

† 'Astron. Nachr.' Nos. 806, 833.

‡ 'Proceedings of the Royal Society,' 1863.

certain standard. Dr. Woods* now suggests a plan which he adopted in 1854† to show the identity of the sun's action on a photographic surface with that of flame, the centre rays of the latter being also more intense in chemical action than those at the circumference. This method consists in exposing the prepared paper to the sun's picture in the camera for a period so short that the centre or most active rays only have time to act upon it; then, for the next impression, to leave the paper exposed for a somewhat longer time, so that a somewhat larger picture is obtained; and so on until the entire picture is given. The size of the impression produced would be in proportion to the time of exposure, and it would appear that the intensity of the chemical rays from any part of the disc would be more accurately fixed by getting the time required for their action than by the use of standard tints.

An important contribution to our knowledge of the light from certain of the fixed stars has been presented to the Royal Society by Mr. Huggins and Dr. Miller. These gentlemen use in their spectroscope two dense flint-glass prisms, and the spectrum is viewed through a small achromatic telescope, with a magnifying power of between five and six diameters. A plano-cylindrical lens of 14-inches focus is employed to convert the image of the star into a narrow line of light, which is made to fall upon a very fine slit, behind which is placed an achromatic collimating lens. The spectroscope so constructed is attached to the eye-end of a refracting telescope of 10-feet focal length with an 8-inch achromatic object-glass, and the whole is mounted equatorially and carried by a clock-movement. By this instrument between forty and fifty of the fixed stars have been more or less completely examined, and tables of the measures of about 90 lines in *Aldebaran*, nearly 80 in *α Orionis*, and 15 in *β Pegasi* are given. In the spectrum of *Aldebaran*, coincidence with nine of the elementary bodies has been observed, *viz.* sodium, magnesium, hydrogen, calcium, iron, bismuth, tellurium, antimony, and mercury. In the spectrum of *α Orionis*, five cases of coincidence were found, *viz.* sodium, magnesium, calcium, iron, and bismuth. *β Pegasi* furnished a spectrum closely resembling that of *α Orionis* in appearance, but much weaker. It was particularly noticed that the lines C and F, corresponding to hydrogen, which are present in nearly all the stars, are wanting in these two stars. In the concluding portion of their paper, the authors apply the facts observed to an explanation of the colours of the stars. They consider that the difference of colour is to be sought in the difference of the constitution of the investing stellar atmospheres, which act by absorbing particular portions of the light emitted by the incandescent solid or liquid photosphere, the light of which in each case they suppose to be of the same quality originally, as it seems to be independent of the chemical nature of its constituents.

The subject of stellar and planetary spectra has been likewise continued by Father Secchi. Taking advantage of the moon being in the neighbourhood of Jupiter and Saturn, he has compared the spectra of the three, and has satisfactorily made out the presence of atmo-

* 'Phil. Mag.' August, 1864. † 'Phil. Mag.' July, 1854.

spheric lines in the spectra of the planets, and the absence of them in that of the moon. This observation appears to show that the so-called atmospheric lines are not, after all, due to the absorbing action of. the earth's atmosphere, or they would be present in the lunar spectrum.

It is well known to all who have devoted attention to photographic chemistry that iodide of silver occurs in two modifications, one being sensitive, whilst the other is insensitive to the action of light. M. Kaiser, of Leipzig, has discovered that the insensitive modification may be transformed into the sensitive iodide by being submitted to the vapour of benzol. He says that the benzol vapour acts by developing ozone in the air, and he has found that an atmosphere ozonized by electricity has precisely the same action. M. Kaiser's experiments with benzol vapour seem to confirm a suspicion entertained by many photographers, that the wet collodion-plate is more sensitive than any other from its containing a small quantity of ozonized ether on its surface, and not because its pores are more open in the wet state than when dry.

Speaking of photography, we transfer the following extract from a note just received from Dr. H. Draper, of New York. He says, "I have succeeded in taking a photograph of the Moon 50 inches in diameter, a size hitherto unapproached, and, in fact, as large as present processes will permit. It required six weeks of steady work, but fully repays me in the imposing effect gained."

The subject of light in relation to chemistry will probably attract much more attention in future than it has hitherte done. Chemists have, however, somewhat neglected the absorption spectra given by metallic and organic solutions in their hunt after fixed lines. At one of the recent meetings of the Chemical Society,* Professor G. G. Stokes, Sec. R.S., favoured the members with a discourse on the detection and discrimination of organic bodies by means of their optical properties. The properties most available for the chemist were colour-production by absorption, fluorescence, and reflection, and in a limited number of instances the phenomena of circular polarization. The professor exhibited a very simple arrangement of apparatus for the purpose of observing the effects of absorption. It consists of a small glass prism, having a refracting angle of 60° mounted vertically at one end of a long wooden tube, the other end of which is closed, with the exception of a narrow slit regulated by a screw; and against the outside of this aperture, and in front of the lamp, a test-tube containing the solution to be examined can be supported by means of elastic bands. When a dilute solution of permanganate of potash is viewed through the prism, the spectrum appears furrowed out with five dark bands of absorption at regular intervals between the fixed lines D and F, and many other coloured liquids, organic and inorganic, exhibit characteristic absorption-bands, by means of which they are capable of identification. In proof of the value of this test to the detection of organic colouring-matters, Professor Stokes stated that Dr. Stenhouse had supplied him with a mixed colouring-matter, in which three of the madder principles were contained—*viz.* alizarin,

* 'Chemical News,' vol. x. p. 283.

purpurin, and rubiacin; and in a piece of the dry material no larger than a pin's head all three substances were distinctly recognized.

The poisonous nature of the green colouring-matters in general use has led to numberless attempts to substitute for them pigments of less danger. At the recent meeting of the Société Stanislas at Nancy, a proposition was made to employ the beautiful green manganate of barium as a pigment. Although very beautiful and comparatively inexpensive, this pigment would still labour under the disadvantage of being poisonous, whilst at the same time it is likely to be deficient in permanence.

Heat.—One of the most important investigations in this branch of science has recently been communicated by Dr. Kopp to the Royal Society. He has been engaged in the determination of the specific heat of an immense number of solid and liquid bodies, and has devised a very simple method of performing the experiment, thus bringing the determination of specific heat out of the restricted sphere of the physical cabinet, with its complicated apparatus, within reach of the ordinary appliances of the chemical laboratory. Dr. Kopp has arrived at the result that each element in the solid state, and at an adequate distance from its melting-point, has one specific or atomic heat; and that for each element it is to be assumed that it has essentially the same specific or atomic heat in the free state and in compounds. The author discusses the applicability of Dulong and Petit's law, and shows that it is not universally applicable. He concludes his memoir with some considerations on the nature of the chemical elements, and shows that chlorine, bromine, and iodine (which are even now regarded by some as peroxides of unknown elements), if compound at all, are not more so than the other elements to which Dulong and Petit's law is considered to apply. If this law were universally valid, it might be concluded that the so-called elements, if they are really compounds of unknown simpler substances, are compounds of the same order, and have the same degree of composition; but with the proof that this law is not universally true, the conclusion to which this result leads loses some of its authority. In a very great number of compounds, the atomic heat gives however, more or less accurately, a measure for the complication of the composition, and the conclusion appears legitimate that for the so-called elements the directly or indirectly determined atomic heats are a measure for the complication of their composition. Carbon and hydrogen, for example, "if not themselves actually simple bodies, are yet simpler compounds of unknown elements than are silicium or oxygen," and still more complex are the large number of elements which may be considered as following Dulong and Petit's law. With reference to the nature of the so-called elements, the author states that it must not be forgotten that his conclusions only give some sort of clue as to which of the present undecomposed bodies are of more complicated and which of simpler composition, but they tell nothing as to what the simpler substances are which are used in the construction of the compound atoms. But even if these conclusions are not free from uncertainty and imperfection, they are well worthy of attention when they bear upon a subject so shrouded in darkness as the nature of the undecomposed bodies.

The passage of hydrogen gas through homogeneous bodies at a high temperature has lately attracted considerable attention on the Continent. Some time ago M. L. Cailletet communicated a note to the French Academy, in which he showed that hydrogen gas would pass through plates of wrought-iron several millimetres thick at a red heat. The author now shows that when the iron is cold, or at a temperature of only 210° C., hydrogen will not traverse a plate of only $\frac{1}{35}$th millimetre in thickness. M. H. Ste. Claire Deville has likewise been continuing his experiments on the same subject. His method of observing the phenomenon is to fill a wrought-iron tube with nitrogen, and place it in a porcelain tube, through which a current of hydrogen is passed. Upon heating the whole in a furnace, and observing the pressure on the inside and on the outside of the iron tube, it is found that that of the interior may become almost double that of the exterior, in consequence of the hydrogen permeating the walls of iron and adding its pressure to that of the nitrogen. Unless the temperature is very high, no nitrogen passes out; but at very exalted temperatures, the author remarked that the internal and external pressures became equalized, in consequence of the intra-molecular spaces becoming so much dilated as to allow the nitrogen to pass freely. M. Deville conceives that if we knew the law of the dilatation of these inter-molecular spaces, we might determine the relative sizes of the molecules of hydrogen and nitrogen.

The same indefatigable experimentalist has been also engaged with M. Troost in perfecting the means of determining high temperatures, and they describe a porcelain apparatus by which they measure a temperature reaching as high as 1530° C. The description is too long to be given here, but the account leaves no doubt that we have now a pyrometer capable of giving very exact indications, and likely to receive important applications. The authors record that, at the temperature above given, copper and silver seemed to be vaporized, and feldspar was fused to a perfectly clear glass. An iron nail, however, showed no signs of fusion.

It has often been observed that a diminution of density occurs when certain minerals are exposed to heat, and, in particular, it was announced by Magnus some years ago, that specimens of idocrase after fusion had diminished considerably in density without undergoing any change of composition. Dr. Phipson has recently repeated this experiment of Magnus, and finds that it is true both for the whole family of garnets as well as for the minerals of the idocrase group. He finds that it is not necessary to melt the minerals, the change of density occurs upon their merely being heated to redness without fusion; and Dr. Phipson has obtained the curious result, that the diminished density thus produced by the action of a red heat is not permanent, but that the specimens in the course of a month or less resume their original specific gravities. Thus three specimens of lime-garnet mellitite from Vesuvius, having an original density respectively of 3·345, 3·350, and 3·349, after being heated to redness for a quarter of an hour and allowed to cool, were found to have their specific gravities diminished respectively to 2·978, 2·980, and 2·977. In one month's time the specific gravities, upon being again determined, were found to have risen to 3·344, 3·350, and 3·345. The author considers it probable that this property will be found to belong more or less to all substances without exception.

It has become an important desideratum for physicists engaged in the investigation of the spectrum lines to be in possession of an instrument which will readily reveal the presence of fixed lines in the heat-spectrum. The ordinary form of thermo-electric battery is inapplicable for this purpose on account of its shape, besides being scarcely delicate enough for rays of feeble intensity. Mr. Crookes has proposed a method of forming a thermo-spectrometer, which will enable physicists to examine and map out the thermal lines of the spectrum as accurately as this can be done with the visible and photographic portion. Instead of using antimony and bismuth bars, it is proposed to use the far more powerful combination of antimony and tellurium. A single row of these bars are soldered together at their alternate ends, and, after being cemented to a temporary but rigid flat surface, the series is ground perfectly flat. This flat side is then cemented to a permanent support of glass, porcelain, ebonite, or other suitable non-conducting material, and the other side (after removal of the temporary supporting-surface) is likewise ground down until the series of bars is no thicker than a card. This side is now cemented to the same kind of supporting material as was used for the other side, and the whole is firmly and securely sealed up, so as to leave only the ends exposed. The end of the pile now appears in the form of a very narrow, slightly-disconnected line, half-an-inch or so in length, and consisting of the extremities of ten or a dozen couples of antimony and tellurium bars, each not larger than a pin. By connecting the extremities of this pile with a sensitive galvanometer, and carrying it along the ultra-red end of the spectrum, keeping the line of extremities parallel with the fixed spectrum lines, it will instantly reveal when a ray of heat shines upon it by a deflection of the needle; and the comparative intensities of the thermic rays can be at the same time ascertained by recording the angular distance to which the needle is deflected.

Electricity.—Although not able to record any striking discovery in electrical science which has taken place during the last quarter, we have noted several ingenious applications of this force, as well as improvements in instruments connected with it. A suggestion of M. Dufour for preventing the explosion of steam-boilers is especially worthy of notice for its ingenuity, as well as for the important results which would attend its successful adoption. Mr. Grove has shown that when water is deprived of the air naturally dissolved in it, and is then heated, it does not boil steadily at any fixed temperature; the temperature rises many degrees above the normal boiling-point, and the liquid then suddenly bursts into tumultuous ebullition; it now remains quiet for a short time whilst the temperature is again accumulating, and the same phenomena are again repeated, increasing in violence until the water is projected into the air with an explosion, the vessel being frequently broken. It is to occurrences of this kind that boiler-explosions are supposed to be most frequently due, and it is the general opinion that if the water could be kept supplied with air, ebullition would take place with perfect regularity. The difficulty has been how to effect this necessary aëration, and M. Dufour now proposes to accomplish it by carrying an insulated platinum-wire into the water, and connecting the wire and the boiler with the opposite poles of a battery. It is imagined that the decomposition of the water will keep it well supplied with gaseous material, and will prevent the ebullition from becoming explosive.

An ingenious modification of the ordinary electrophorus has been devised by Messrs. Cornelius and Baker, of the Franklin Institute, for lighting gas. It consists of a spherical cup of brass lined with sheep-skin and silk, into which drops a corresponding hemisphere of hard india-rubber. The brass cup communicates with a wire near the jet. To light the gas, the hard-rubber hemisphere is raised by means of a little handle, and the spark passes, lighting the gas in its passage. They have also devised a portable electrophorus of tubular construction; it consists of two brass tubes, united together by a ring of hard india-rubber, closed at each end, and covered internally with a silk padding. Inside the tubes is a cylinder of hard rubber, which passes freely down the tubes when they are reversed. The apparatus is grasped by the non-conducting ring and held upright, the hard-rubber cylinder being at the lower end. Upon reversal it passes to the other end, charging the brass tube in its passage.

Father Secchi advises the use of fine sand or of powdered sulphur in the porous cell of the Daniel's battery, in order to increase its constancy. He accounts for its action by supposing that when the ordinary liquid alone is used, there is greater liability to local action taking place upon the zinc. In a battery, the circuit of which is closed for two minutes every quarter of an hour, the learned father has used an ordinary piece of commercial sheet-zinc half-a-millimetre in thickness, which has continued in action for more than six months without showing the least sign of local corrosion.

Our enterprising French neighbours, always before us in luxurious applications of science, are rapidly applying the electric light to the illumination of private and public assemblies. It has for some time past been introduced at the Tuileries on the nights of the grand balls, and the Abbé Moigno has lately made use of it during his lectures on the progress of science in the hall of the Société d'Encouragement. Instead of being illuminated by the innumerable jets of gas with which the hall is provided, a single electric light placed in a central position lit the room in the most perfect manner. The consequence was that, although the lecture was delivered during the height of the hot season in Paris, the room was kept comparatively cool.

The celebrated electrical instrument maker, Rhumkorff, has deservedly been presented with the Napoleon III. prize of 50,000 francs for the induction apparatus that bears his name. The King of Hanover has also sent him a large gold medal.

IX. ZOOLOGY AND ANIMAL PHYSIOLOGY.

It is stated that researches have been recently carried on in Borneo, on the most extensive scale, with a view to solve the oft-disputed question of the plurality of species amongst the orang-outangs of that island, and that Dr. E. P. Houghton is about to submit a very large collection of skulls of the different varieties or species to English zoologists.

The Aye-aye (*Cheiromys Madagascariensis*), an anomalous creature, which has lately attracted more attention from the fact of a living specimen being successfully brought to the Zoological Gardens, has formed the subject of a memoir by Dr. Peters, before the Berlin Academy. It had been shown by Professor Owen to be allied to the Lemurs, while the structure of the incisors shows an important relation to the Rodents. Dr. Peters concludes that, if we are not prepared to make a separate order for this genus, to be placed intermediate between the quadrumana and the rodents, as Brandt has proposed, it would, on the whole, be the most natural to regard it as an aberrant division of the Lemurs, and to unite it with them to form the representatives of a particular family. With the exception of the disposition of the hands and the opposable thumb of the hinder extremity, the principal character to be considered is the formation of the skull and brain. As regards the dentition, it would be of much interest to investigate whether at any period of the fœtal life of the glires there exist teeth corresponding to the milk-teeth of the aye-aye, the formula of which exhibits a close relation to that of the insectivora.

The sudden occurrence of Pallas' sand grouse (*Syrrhaptes paradoxus*) over the greater part of Europe has attracted the attention of ornithologists, and Mr. Alfred Newton has collected information which shows that this remarkable bird, hitherto almost unknown to the European fauna, has been met with during the year 1863 in no less than 148 localities in Europe and Great Britain, tracing the invading host through 33° of longitude from Galicia to Donegal. He regards the proximate cause of this wonderful movement to the natural overflow of the population of *Syrrhaptes*, resulting from its ordinary increase, being a bird which has comparatively few enemies, while its time of incubation is short in comparison with what it is in most ground-breeding birds. Mr. Newton inclines, from the remarkable form of the primaries of the wing, the filiform tail feathers, and syndactylous feet, to believe that the sand grouse is not improbably "the conquering hero of a long struggle for existence," and striving to extend its range in all directions; and he predicts that unless some physical change occurs in the Tartar steppes which may have the effect of relieving the internal pressure, another outpouring may be safely predicted.

Mr. Allis exhibited to the Linnean Society bones and photographs of a Dinornis, of which the skeleton is nearly perfect. Out of nine left ribs seven are still *in situ*, and the sternum is perfect and as fresh to appearance as though the bird had been alive last year. The inner left toe has the whole of the outer sole still adhering to it, as well as part of the sole of the foot. On the lower part of the back is still a considerable portion of the outer skin studded with the quill part of the feathers, and in one or two rare instances portions of the web of the feather. The bones of the neck still show greater or less marks of having been within reach of the destructive effects of the atmosphere, while the head at one extremity, and the first dorsal vertebra at the other, are each as perfect as though they had been taken from a fresh killed bird by the most skilful anatomist. Mr. Gibson, a resident in New Zealand, sent it to his brother, Dr. Gibson, of York, with a statement that it was discovered in a sand-hill, sitting on its eggs, by some diggers, about 100 miles up the country from Dunedin, to which place it was sent for sale. When the boxes were opened they were thought to contain only the bones of one adult bird, but an examination showed a number of small bones belonging to very young birds, its brood, consisting of five individuals. Dr. Hooker suggested that the perfect condition and high preservation of the bones might be due to ice; but Professor Huxley and others took a different view of the subject, and thought that the bird in question had probably been living within ten years. When we remember that in the Great Sahara the ostrich is only to be discovered at an immense distance, although there are no intervening objects behind which he could shelter, the moa, if possessed of half the subtlety of the ostrich, might escape for years the notice of the few Europeans who have ventured to intrude on his haunts, and it is by no means impossible that this gigantic bird may exist to this day undiscovered. Explorations of the middle island are being made by Dr. Haast which promise soon to settle this interesting question.

The great interest attending the discovery of remains of animals recently extinct, or concerning whose present existence zoologists are in great doubt, has led Mr. Alfred Newton to follow up the researches of the late Mr. John Wolley upon the great Auk, or Gare fowl (*Alca impennis*), which he has done so successfully as to have secured from Funk or Penguin Island, 170 miles north of St. John's, Newfoundland, a natural mummy of that curious bird, which vies with the dodo in ornithological interest. Although numerous skins of the bird exist in various museums of Europe, the osteology was very imperfectly known, and the present mummy is, with one exception, the only approach to a complete skeleton existing in Europe. Mr. Newton has placed it in the hands of Professor Owen, from whom no doubt we shall receive an elaborate monograph upon the subject.

Mr. William Bennett gives an account of his attempts at breeding Emeus (*Dromius*) in Surrey, which throw some light upon the economy of struthious birds. In 1863 the female continued laying until she had deposited twenty-eight eggs, weighing about forty pounds. The male bird was set upon fourteen of these, and the remainder placed in an incubator. For a month all went on well, but in the fifth week the birds were so greatly excited by the appearance of a boat, that the eggs were left. Those in the incubator all failed also, although the chicks had nearly reached maturity. A new lot of eggs began to be deposited on December 23rd, and on February 14th (of the present year) the male commenced sitting on ten eggs. After eight weeks, signs of life appeared in the eggs, and on April 13th the first was hatched, and ultimately ten young emeus repaid Mr. Bennett's care and labour. The normal period of incubation thus appears to be about sixty days, but although the number of eggs laid is large, few appear to be hatched in the wild state, as the eggs are laid in various sheltered places, and are afterwards collected by the male, that is, as many as he may happen to find. The female takes no part in incubation.

A series of experiments has been made by M. Barthélemy on monstrosities, both artificial and natural, among lepidopterous insects. He performed his experiments chiefly on the chrysalis, and endeavoured to cause modifications similar to those obtained by covering the eggs of birds with varnish. On covering the chrysalis with oil it was found that it died before completing the metamorphosis; but on covering either the thoracic or abnormal portion with wax, a retardation of development was perceived, which was much greater in the case of the thoracic parts. The cephalic part of the nervous system was much retarded in development, but the other parts of the ganglionic chain appeared to be developed as usual. He succeeded also in suppressing the development of the generative organs.

Mr. Bates has added another remarkable example of mimetic resemblance, in a spider, of the genus Salticus, to a flower of Senecio pubigerus (Linn.), a common roadside weed in dry ground about Cape Town. It was noticed by Mr. Roland Trimen, of Cape Town, who says:—

"Leptoneura Clytus, a handsome butterfly of the Satyrus family, is very abundant just now. Flowers are rather scarce at this season, and a tall straggling plant with yellow composite flowers attracts these butterflies with many other insects. As I approached a plant upon which were several Leptoneuræ, I observed that two specimens did not fly off with the others, and found that each was in the clutches of a bright yellow spider. I removed one of these butterflies, and as the spider shrunk up its limbs on the flower, which equals it in size, it was scarcely distinguishable, so exactly similar was it in colour. Recovering from its alarm, it slowly moved to the side of the flower, and holding on to the stalk by its two hindmost pairs of legs, it extended the two front pairs upwards and laterally. In this position it was scarcely possible to believe that it was not a flower seen in profile, the rounded abdomen representing the central mass of florets, and the extended legs the florets of the ray; while to complete the illusion, the front femora appressed to the thorax have each a longitudinal red stripe, representing the ferruginous stripe on the sepals of the flower. As the other spider also assumed the same attitude when robbed of his butterfly, and as both retained it for a considerable time, I conclude it is their ordinary mode of waiting for their prey."

M. Matteucci brought before the French Academy a remarkable case, in which a number of eggs, after having been allowed to remain under the hen for different periods, were left to putrify. In no case did he find the slightest trace of either animal or vegetable life upon breaking the shell of the putrified eggs. He considered that as long as the shell remained intact no germs could by any means obtain admission, and therefore the circumstances of this case were peculiarly favourable for experiment as to the possibility of spontaneous generation. M. Milne-Edwards, however, stated that M. Panceri had shown that the shell is not always impervious to the passage of organized bodies.

The subject of spontaneous generation is still occupying considerable attention both in France and England. Messrs. Pouchet, Joly, and Musset are endeavouring to prove by their experiments that the air does not normally contain the incalculable number of ova and spores ascribed to it by M. Pasteur. That shown, they engage to prove that with a boiled fermentable substance to be left to their choice, organized productions shall be constantly and universally obtained in vessels hermetically sealed, and containing a cubic decimeter of atmospheric air. The statement of M. Pasteur, on the other hand, is, that it is possible to obtain in a given place a sufficient but limited quantity of atmospheric air, having undergone no kind of physical or chemical alteration, capable, nevertheless, of causing an alteration in an eminently putrescible liquid.

Dr. Child, of Oxford, has laid some experiments before the Royal Society, made during the summer of 1863, in which milk or fragments of meat and water were placed in bulbs of glass 2½ inches in diameter —some of the bulbs being filled with air previously passed through a porcelain tube containing fragments of pumice-stone, and heated to vivid redness in a furnace; while others were filled respectively with carbonic acid, hydrogen, oxygen, and nitrogen gases. Some of the substances were boiled from five to twenty minutes, in all cases in the bulb, and with the stream of gas or air still passing through. The microscopic examination of the contents took place at various times from three to four months after their enclosure. When the substances had not been boiled, in every case but one, low organisms were found; and when the substances were boiled the results were:—in the carbonic acid and hydrogen experiments, no sign of life; in the heated air and oxygen experiments, organisms were found; and also in the nitrogen experiments where meat was used, but none where milk was used. It is worthy of remark that in these experiments organisms were found under the precise circumstances in which M. Pasteur states that they cannot and do not exist.

M. Coste has laid before the French Academy some important observations on the development of ciliated Infusoria, which in many points oppose the doctrines of M. Pouchet. Infusoria, he affirms, make their appearance in an infusion long before the pellicle, falsely called *stroma*, a name which attributes a function to it that it does not possess. They are introduced either as eggs or cysts with the hay, moss, or leaves of which the infusion is made. Although the *stroma* is produced in infusions made with substances which are not exposed to the air, such as the pulp of the apple, infusoria are never found in such infusions if the vessel be covered with a piece of glass. Nevertheless, if, after ten or twenty days, no infusorium be visible, and two or three Kolpods, or Chilodons, or Glaucomas be introduced, these species will soon show themselves in prodigious numbers, in consequence of their mode of immediate multiplication by division. Some, as the Glaucomas, Chilodons, and Paramecia, divide themselves without encysting; others, like the Kolpods, encyst themselves before division. After multiplying by division in the interior of their cyst, the Kolpods encyst themselves again, and remain in that state until the infusion is completely dried up, and they return to life only after a fresh moistening. Filters, however, allow small infusoria, such as Kolpods, Chilodons, &c., their cysts and eggs, to pass through them.

X. SCIENCE IN THE PROVINCES.

The numerous provincial Societies, not behindhand in advancing the cause of scientific progress to which they have allied themselves, exhibit an amount of activity worthy of the cause, and which shows itself from time to time in the publication of Proceedings which are often of great interest and value. Many of these have forwarded to us an account of their labours, and it affords us great pleasure to lay before our readers a brief summary, as evinced by these published results. Those who disparage everything provincial, cannot fail to observe that the Metropolis stands foremost solely because there is concentrated, as in a focus, the chief talent of the country; and that, therefore, there can be no reason to despise the lucubrations of Societies which include the names of Joshua Alder, Rev. A. M. Norman, Albany Hancock, Rev. L. Jenyns, W. Pengelly, C. Spence Bate, and many others.

Among such provincial Societies, the 'Tyneside Naturalists' Field Club' occupies a prominent position, and periodically publishes Transactions which are full of interest. The latest number is a worthy successor to many others. Among the chief objects of this Society is the publication of catalogues of the natural productions of Northumberland and Durham, and from time to time the Coleoptera by Messrs. Hardy and Bold, the Mollusca by Mr. Alder, the Zoophytes by the same, the Permian Fossils by R. Howse, the Lepidoptera by G. Wailes, and Marine Algæ by G. S. Brady, have appeared; while the freshwater Algæ, Foraminifera, Echinodermata, Annelida, Crustacea, Hymenoptera, Hemiptera, Birds, and fossil Fish are in progress. The present number contains a most interesting "catalogue" of the Mammalia, by Messrs. Mennell and Perkins, occupying about sixty-five pages, and abounding in information both technical and popular. It is a model of what such Fauna lists should be, and we wish that every county of our island had so excellent a chance of being thoroughly examined and elucidated as have those of Northumberland and Durham. Fifty out of the sixty-seven wild British species are claimed for those two counties.

Mr. G. S. Brady, whose attention is directed to the Entomostraca, has added several of these organisms to the British lists, by the discovery of three species of Cypris and two of Candona in the above counties, which are here described and figured. One of these, Cypris affinis, was known as an inhabitant of the Continent, but has recently been taken in both the northern counties; and another species found there is of great interest, inasmuch as it was first described as a tertiary specimen by Rupert Jones, but has since been discovered in brackish water at Gravesend, and at Warkworth.

The British Association, at its Cambridge meeting, renewed a grant for dredging the Dogger Bank, and the coasts of Northumberland and Durham. These explorations have resulted in several interesting and new forms, including a beautiful nudibranchiate mollusk (*Hero formosa*, Lovèn), which occurs on the coasts of Norway and Sweden. The Durham coast, however, is described as generally poor in Mollusca, which have a boreal type, approaching more nearly to the Scandinavian than to the South of England fauna. Mr. Alder gives a report upon these, while Rev. A. M. Norman reports upon the Crustacea, which includes specimens of Sacculina and Peltogaster, rare forms which are found parasitic upon the abdomen of various stalk-eyed Crustacea. The Echinodermata yielded a rich return, including a new species (*Ophiura squamosa*, Lütken), and Mr. Alder describes among the collection of Zoophytes a new Scrupocellaria (*Delilii*), and other remarkable forms.

In further proof of what we have observed concerning the working of this provincial Society, we must also refer to Mr. Hodge's list of the British Pycnogons (Araneoid crustacea), in which thirty-two species are included, ten of which are new. These are described and figured by the author.

'The Woolhope Naturalists' Field Club' principally employs itself with the Natural History of Herefordshire; and the fifth number of its Transactions is chiefly occupied with an elaborate and exhaustive treatise on the 'Mistletoe in Herefordshire,' by Dr. Bull. This paper contains a great amount of information concerning this interesting parasite—the mode of its propagation and growth—the trees it lives upon in this country—the recorded history of its growth on the oak in England—and the romance of its history as developed in times past and present. Thirty trees are mentioned as bearing mistletoe, including apple, seven species of poplar, hawthorn, crab, lime, maple, acacia, flowering-ash, willow, hazel, alder, sycamore, elm, horse-chestnut, &c.; but the favourite site of the mistletoe is certainly the *apple-tree.* The actual numbers were 784 trees with mistletoe, and 1,218 without it—or from other sources, a general average of 34 per cent. Mistletoe is never seen to grow spontaneously upon the beech, birch, bird cherry, wild cherry, sloe, hornbeam, elder, holly, dogwood, box, Lombardy poplar, sweet-chestnut, walnut, laurel, nor on any other of the many introduced varieties of trees and evergreens. Only six well-authenticated instances are recorded of its growing upon the *oak*, throughout England, although others have been noticed which were either erroneous or have now ceased to exist.

'The Devonshire Association for the Advancement of Science, Literature, and Art,' held its third Annual Meeting in July at Torquay, under the presidency of Mr. Vivian, and after an inaugural address, several papers of considerable interest were read, among which were:

Mr. Hearder, of Plymouth, 'On the Preservation of the Iron-plating of Wooden Ships from the Corrosive Action of Sea-water.' It having been found that large holes had been made in a new 5-inch plating, he proposed to place gutta-percha or india-rubber between the iron and the copper-sheathing, and, if necessary, a band of zinc also on the inside of the plating, to prevent even the possibility of communication with the copper.

Mr. Spence Bate described a kitchen-midden recently found in the north-east of Cornwall, an ancient Cornish barrow, and a Romano-British burying-ground. The midden was accidentally discovered in Constantine Bay, and consisted of limpet, mussel, and whelk shells, bits of greenstone probably used as hammers, and flint, bones of the red-deer, ox, sheep, and lamb, pieces of pottery, &c. The midden, he believed, indicated the site of a very extensive village of pre-historic man. Near the midden was found a barrow, or circular mound, 100 feet in diameter. Within it, in a cavity covered by a stone, had been found an earthenware vase containing human bones partly burnt. The burial-ground was discovered in making the excavations from Fort Stamford, near Plymouth. Underneath blocks of limestone had been found bones, pottery, bronze armlets, fibulæ, mirrors, a small dagger, and pieces of partly-decomposed iron, finger-rings, scissors, &c.

Visits to Brixham Caves and Berry Head gave Mr. Pengelly an opportunity of calling attention to extraordinary geological phenomena. The Devonian limestone is traversed by two systems of joints, one north and south, and the other east and west. Some of these are occupied by dykes of fine triassic sandstone. A careful study of these rocks proves that an almost incalculable period must have elapsed since the joints first opened, for there is—1st. The filling in of the east and west open joints with red sand, at a period not earlier than, if so early as, the commencement of the Torbay trias. 2nd. The induration of the sand with coherent and durable dykes capable of being fissured and faulted without their sides falling in. 3rd. The formation of longitudinal fissures in dykes. 4th. The gradual filling of these fissures, not with sand, but by the precipitation of carbonate of lime. 5th. The formation of transverse joints passing in a north and south direction alike through the triassic dykes and veins, and the pre-triassic rocks. 6th. The faulting of the entire mass—rocks, dykes, and veins—by inequalities of movement in an approximately horizontal direction; and 7th. The filling in of the north and south open joints with red sand as in the first instance, so as to form dykes, passing through those previously existing, the two systems being distinguished by well-defined walls, and a marked difference in colours. The triassic rocks, it should be remembered, in making calculations of time, are a mere sub-division—and that the lowest—of the mesozoic group. These facts appear to Mr. Pengelly to show conclusively that the rocks in which they occur, are the exponents of a lapse of ages great beyond human conception. This interesting paper has been separately published by Mr. Pengelly with illustrative figures.

The 'Torquay Natural History Society,' of which Mr. Pengelly is president, has also had the advantage of an admirable address from that gentleman; in which he ably reviewed the events of the past year, naturally dwelling upon those geological discoveries which have caused so much discussion in relation to the disputed antiquity of man, and gave a well-digested summary of the evidence afforded by the discovery of the shell-mounds of Denmark, the lake dwellings of Switzerland, the elephant remains at Saint Prest, near Chartres, and the quaternary gravels of the Somme. Nor did the questions of Anthropology meet with less than their share of criticism; and the opinions of Waitz, Huxley, and others, received considerable attention. Professor Max Müller's view of the original unity of all existing languages, and Mr. Crawfurd's counter-view, were also set forth, with a strongly expressed opinion against the former. The whole address forms an excellent and philosophic summary of these leading scientific topics of the day from the pen of one well able to deal with them, and to express an independent opinion.

'The Plymouth Institution and Devon and Cornwall Natural History Society,' is another active body in the West of England, one of whose objects is, like the 'Tyneside Club,' the cataloguing of the natural productions of those counties. The last published number of their Transactions contains lists of the mammals, birds, reptiles, amphibia and lepidopterous insects of Devon, which cannot fail to be of service in elucidating the general natural history and distribution of animals in these islands. It is also enriched with a paper by Mr. Pengelly, on the Red Sandstone, Conglomerates, and Marls of Devonshire.

Other Western Societies which are keeping up the lamp of science with assiduity, are the 'Bristol Naturalists' Society,' whose monthly Proceedings find a place in the 'British Daily Post'; and the 'Bath Natural History and Antiquarian Field Club,' whose president is the Rev. Leonard Jenyns. An admirable address from this venerable naturalist to the club now lies before us, but our space will only allow us to thus briefly refer to it.

In the Eastern district and near London, the 'West Kent Natural History, Microscopical, and Photographic Society,' which has absorbed the 'Greenwich Field Naturalists' Club,' and is supported by many leading scientific men of London, whose residence outside the metropolis enables them thus to meet periodically on Blackheath, for the prosecution of their favourite pursuits. Of this club the excellent Linnæan Secretary, Mr. Currey, is president, and a most interesting address from him, on the progress of science, has been circulated.

Among naturalists' field clubs, however, none have met with so surprising success as that at Liverpool. This club was established at Liverpool in 1860, the year following the foundation of a similar club at Manchester; but the former has outstepped the latter, and its steadily increasing number of members has now reached about 700. There can be no question that this club has done much to disseminate a taste for and knowledge of natural history, more especially of botany, in Liverpool. During the winter months periodical meetings are held, at which lectures are delivered and specimens exhibited, in which the aid of the microscope is largely used; and in summer, excursions to a greater or lesser distance into the country are taken, at average intervals of three weeks, on which occasion prizes are offered, which are calculated to stimulate the taste for botanical pursuits. These prizes consist of books of the value of half-a-guinea, of which several are offered at each excursion, *viz.* for the collection, naming, and arrangement in natural orders of the largest number of species in flower; for the largest illustration of some given natural order; and for the simple collection of the largest number of species in flower. In addition to these, numerous prizes are offered for collections to be made during the year, which have met with the most encouraging success. Nor should it be omitted to be mentioned, that twice has this club held high festival in the magnificent St. George's Hall, on which occasions extraordinary exhibitions of the most varied and most valuable natural objects have been made, and certainly forming the most remarkable natural history festivals which it has ever been our lot to witness.

The 'Cambridge University Natural Science Society,' which has sprung from a University Club, is a new Society, and if we may judge from the earnest spirit of the address of its President, Mr. C. W. Villiers Bradford, it is one which is destined to do considerable service. The subject of the position of Natural Science in the University curriculum, and the encouragement given to its prosecution, is brought forward in a prominent manner. The Natural Science Tripos standard was raised in 1861, so that a first class in that Tripos was equivalent to the position of a Wrangler. The numbers availing themselves of the Tripos, however, have been very small, owing to the little encouragement offered by the University and Colleges. Out of twenty-two University prizes, not one is devoted to any department of Natural Science; and out of the seventeen colleges which compose this commonwealth of learning, only *three* offer any pecuniary inducement to scientific study, *viz.* Caius, Sidney Sussex, and Downing Colleges; while no college has ever yet given a fellowship for Natural Science alone. At Oxford this, however, is the case, and members of both Universities are allowed to compete. So long, therefore, as the colleges of Cambridge refuse to extend to science that stimulus to energetic work which every other branch of study possesses, we may predicate for the Natural Science school but a struggle for existence there. Few men who go to a University can afford to spend their school and college days in competing for an empty honour, while the same time and labour differently bestowed may ensure a provision for the early years of a profession; but when Fellowships are given equally for science, mathematics, and classics, possibly even a greater competition may be expected in the former case than in the two latter, and perhaps the Fellows of colleges foresee this. The University prizes are restricted in their object; the Scholarships also are but partially free from similar trammels, but the Fellowships are entirely in the hands of the Masters and Fellows of colleges. But, although the colleges show so little favour to science, there are six Professors of high reputation, and also well-stocked geological, mineralogical, and anatomical museums, numerous laboratories, a magnificent collection of scientific books in the University Library, and an excellent botanic garden; but the Professors require assistants, and the collections require curators. We sympathize with the Cambridge University Natural Science Society in its attempts to arouse the University to a sense of its shortcomings, which place it in the rear of other similar noble educational establishments; and we hope that, ere long, the attention which is thus called to these wants may fulfil the object which they have in view, and that their laudable endeavours may be crowned with complete success.

XI. SCIENCE IN ASIA.

Great were the advantages conferred on science by the foundation of the Asiatic Society of Bengal. It has given a start to much scientific investigation, and seems to promise much in the future. It is on the point of conferring an immense benefit on society at large in Calcutta by placing its extensive Museum in the hands of the Government, while it gives valuable assistance to individual collectors by forming a means of communication between zoologists in all parts of India. This last object it is intended to carry out according to a plan proposed by Mr. C. Horne, by means of lists of all naturalists, numismatists, and others who wish to enrol themselves as desirous of exchanging their duplicate specimens. It is not intended to confine these lists to members of the Society, but to admit all who are willing to join. Other scientific bodies are coming into existence, amongst which we may mention the Dalhousie Institute, which has had a site afforded it by the Government, on which a suitable building is to be erected as soon as an opportunity is offered for the Governor-General to lay the foundation stone. At Allahabad, moreover, a museum and a library are on the point of being established. A circular has been issued by Dr. Cunningham, the curator and secretary of the future institution, to all the Government officials to collect materials under the six following classes:—

- A. Specimens illustrative of antiquity, such as old coins, MSS., arms, &c.
- B. Raw materials.
- C. Agricultural produce. (Is this not included under the preceding head?)
- D. Manufactured goods.
- E. Specimens illustrative of natural history.
- F. Models of machinery.

To the library the curator hopes to attract the legacies of officers and Government servants departing for Europe, expectations that probably may be realized if we consider the enormous expense of carriage which would be incurred in bringing home books. A site has not as yet been assigned, but it is probable that the Government will shortly provide one.

Hindû ignorance is an obstacle to many investigations. We cannot but rejoice to see so many native contributors to the proceedings of the Asiatic Society, and hope that much enlightenment may gradually spread amid all classes. Old religious prejudices are breaking down; the Suttee has disappeared. It appears that Juggernaut does not so readily procure victims as formerly, and it is actually proposed to check the possibility of this sacrifice of human life. But further than this, female education is gradually engaging the serious and earnest attention of the liberal-minded and influential circles of the Hindû community of Bengal. A Hindû gentleman, Baboo Gunja Gopal Chatterjee, has opened an entirely free school for girls on the western bank of the Hooghly. About forty attend, many of Brahminical caste. In the Madras presidency a more extensive movement has taken place—nothing short of a complete reformation—including the endeavour to promote female education, to discourage polygamy, and to encourage the re-marriage of widows. The religious views of the promoters of this movement are monotheistic, and all sectarian tendencies are discarded. But as a set-off against these advances in the way of education, we must record an instance of extreme bigotry on the part of some Mahometans in this same presidency. Two officers who attempted to visit the famous tombs of Golconda were vigorously abused and then pelted. From this attack of three or four hundred men they effectually defended themselves with whips, but when their assailants had been reinforced by some hundreds of villagers they seriously maltreated the officers, who escaped violence indeed, but who had to return without visiting the tombs.

The 'Journal of the Asiatic Society of Bengal' for the present year opens with a paper on "The History of the Burmah Race," by the Chief Commissioner of British Burmah, Lieutenant-Colonel A. P. Phayre, C.B. This gentleman has collected his information from a copy of the chronicles of the Kings of Burmah, entitled 'Maha Radza Weng,' presented to him by the reigning monarch, a man of some learning, who has caused a new edition of these annals to be compiled under his own immediate direction.

The conclusions arrived at by Lieutenant-Colonel Phayre from these accounts are in the main in agreement with the theory of Prichard, displayed in his 'Natural History of Man,' *viz.* that the Burmese race, in common with the peoples to the north and west of them, have descended from the high land of central Asia by the courses of the great rivers, and have thus overspread the low lands. Three tribes, the Burmese, the Karens, and the Mon, seem to have found their way southward along the courses of the Salween and Meenam; the first and last of these reached at an early period the upper part of the valley of the Irrawaddy; the Karens remained till of late in the mountains, but have now penetrated into the same valley, and have pushed onwards along the mountains of the sea coast. The traditions of migrations from India are supposed to have been invented after their conversion to Budhism by missionaries from Gangetic India, for the purpose of connecting their own royal family with those of the reigning Budhist families in India. This conversion seems to have taken place whilst the capital was at Tagoung, since a Budhist image was discovered there inscribed with a well-known religious text in Deva-nagri characters, which bear a close resemblance to similar inscriptions at Allahabad. Now the Burmese and Tapaing writing of the present day is undoubtedly derived from the Deva-nagri character, but it also bears upon the surface of it a distinct impress of the Tamulic letters. We may well argue, therefore, that these few inscriptions were the work of the earlier Budhists that came from India, and who seem to have settled at Tagoung but a short time before it was overrun by the Tatar or Chinese race, whom the Burmese call Ta-ret or Ta-rook. The real origin of the race, then, was in the interior of the continent, but their traditions, founded on religious prejudices, point to an Indian birthplace.

In these days, when pisciculture is becoming attractive both to the man of science and even to the economist, the remarks of Mr. E. O'Reilly, the Deputy-Commissioner of Bassein, on the immense profits made from the fishing in the Lake of Clear Water in the district of Bassein, in Burmah, will be read with great interest. The lake to which these remarks refer is of a peculiar character, having but one stream which flows into it when the Irrawaddy, and in consequence the Bassein and its dependant, the Dugga, are swollen, and out of it when these rivers shrink again to their accustomed channels. The lake thus forms a natural preserve, and from its ring-shape it affords peculiar facilities for dragging. When the lake is at its lowest a fixed weir is built on one side of the outlet, and a drag-net, made of reeds, grass, and jungle-creepers, about 1,800 cubits long, is made on the other. This latter is moved gradually forward at the rate of about forty-five fathoms a-day for three months, until it is brought nearly opposite to the village on the shore of the lake, at a distance from its mouth. A bamboo weir is then erected to prevent the return of the fish, and the drag-net is taken to pieces and reconstructed by the first-mentioned weir, and then again dragged back in a contrary direction until it approaches the village on the other side. The fish are thus left cooped up until the first showers of the monsoon have cooled the water and the atmosphere, and then at the full moon in June the merchants assemble from Prome, Ava, and the other large towns on the Irrawaddy to attend the actual haul. Upwards of forty tons of fish are annually disposed of to these visitors, some in the form of dried fish, but also a large quantity is bought by the dealers from the lower parts of the river alive, and this is by them transported in bamboo cages kept under water. In the whole province of Pegu it is calculated that upwards of 1,800 tons of fresh-water fish are used by the natives, affording a very large source of revenue to the Government.

The condition of the dependency of Bustar, according to the report of Captain C. Glasfurd, Deputy-Commissioner of the Upper Godavery District, does not hold out any great enticement to the archæologist. The present, as well as the late dynasties of rajahs, seem to have had but little taste or liking for architecture; but about five hundred years ago there reigned in Barsoor a family of rulers who have left several monuments of their power, though the neglect of later times has suffered these to fall into almost total decay. These ruins are enclosed by a wall forming a square of about a mile. Within this are the remains of four or five temples—massive, handsome, and richly sculptured. They are built of huge blocks of gneiss, put together without mortar. They owe their destruction principally to the insinuation of the roots of the *Ficus Indica.* A slab of stone was found inscribed with Sanskrit and Teloogoo characters, the latter so antiquated that they have not as yet been deciphered. A large tank in good repair was found near at hand, and about 150 tanks have been reckoned within a circuit of fifteen miles. A similar enclosure with temples was found at Duntewara, on the western bank of the Dunkunee; but at Madhota, one of the ancient capitals of the district, no ruins beyond mud walls were to be found.

The hot springs of India, not including petroleum wells, have been enumerated by Robert de Schlagintweit, Esq. They amount to ninety-nine in number. The hottest (202° Fahr.) is at Manikárn, in Kúlu, amongst the Himalayan provinces, and is 5,587 feet above the sea-level. The highest is at Momái, in Sikkim, in the same locality, and is about 16,000 feet high; the heat is 110° Fahr.

The original papers end with a memorandum on some ancient tiles found at Pugan, which have Budhist figures and inscriptions on them.

Amongst the proceedings of the Society it is interesting to observe how much mutual assistance is evinced between the promoters of Oriental literature in Europe and those in Asia. Dr. Weber writes an account of the progress of such work in Europe, especially in Germany, noticing the appearance of the second volume of Pictet's 'Origines Indo-Européennes,' and regretting the scholastic employments of Kuhn did not allow him to devote his whole time and attention to comparative mythology. A discussion on the Andaman Islanders arose at one of the meetings, after a paper read by the Rev. Wm. Corbyn. We are very glad to perceive that the indolent and unscientific argument that when a civilized and powerful race comes in contact with an ignorant and degraded people, the extermination of the latter must follow as a natural consequence, was met and combated by Mr. Cowell (whose return to England in consequence of ill health will be a great loss to this Society, to the college of which he is such a distinguished professor, and to Indian literature generally) and also by the president. The latter adduced as an instance in point the case of the Laps in conjunction with the Russians. That nation has neither decreased in numbers nor deteriorated in condition since the commencement of the last century; but then they have neither been subject to the example of the most degraded specimens of vicious civilization, harassed by petty injustice, nor enticed into such courses as must lead to their destruction. Great praise is due to Mr. Corbyn for what he has done and is doing for this almost hopeless race of human beings.

The journal concludes with an elaborate abstract of the meteorological observations taken at the Surveyor-General's office at Calcutta, from August, 1863, to the end of the year. The following results may be noticed:—

	Inches.
The maximum height of the barometer was on December 19th, at 10 a.m. . . .	30·153
The minimum height on the 17th August, at 5 a.m.	29·35
The mean daily range of the barometer during August	0·109
,, ,, ,, September .	·124
,, ,, ,, October .	·124
,, ,, ,, November .	·125
,, ,, ,, December .	·134
The greatest range of the barometer in one month was in October, of an inch . .	·48
The maximum temperature in August . .	90·6
,, ,, September .	90·6
,, ,, October . .	90·4
,, ,, November .	86·3
,, ,, December .	79·7
The minimum temperature in August . .	75·4
,, ,, September .	77·8
,, ,, October . .	72.2
,, ,, November .	61·6
,, ,, December .	56·4
The total amount of rain that fell in August (24 days)	14·1
,, ,, ,, September (23 days)	10·33
,, ,, ,, October (9 days)	3·48
,, ,, ,, November (3 days)	1·26
,, ,, ,, December	nil.

REVIEWS.

THE SCIENCE OF LANGUAGE.*

The Science of Language is in one point of view the youngest of the sciences. Though we can scarcely imagine a period at which this subject was not studied in an empirical manner, still, as a science resting on induction and logic, it has existed but a few years. Thus it is scarcely possible to state a period at which the history of Philology should begin, but it is only of late years that anything like scientific arrangements or definite laws have been discovered.

As before geology was studied scientifically, many a collector possessed a museum containing curiosities from his own neighbourhood, illustrating a particular class of rocks, so before philology (or Linguistics, as Mr. Marsh would call it) had arrived at well-ascertained laws or systematic classification, many a student of one or two languages had collected specimens of "fossil history and fossil poetry" dug from the mines of dusty books, even preserved from the rubbish-heaps lying at his doors, all which material will one day be arranged and labelled and inserted in catalogues, causing their language to become to the learned "a dictionary of faded metaphors."

The man who seems to have been the first to recognize the necessity of extensive induction before general laws could be discovered was Leibnitz, the contemporary of Newton. In order to place this study on a really philosophical basis, he entreated all those who had any chance of assisting him—such as missionaries, travellers, &c.—to collect the elements of whatever strange dialects it might be their fortune to meet with. Leibnitz possessed the advantage, not common to great thinkers, of being intimate with some of the leading political characters of his day, and amongst others with the Czar, Peter the Great. To the Emperor of all the Russias this philosopher pointed out the immense advantage that might be derived at small cost to the Russian Government, if he would cause the numerous dialects of the various races under his rule to be committed to writing. No immediate fruit resulted from this advice, but nearly a hundred years later the Empress Catharine took up the idea, and devoted a considerable amount of time to the work of compiling a Comparative Dictionary. For this purpose she procured lists of words, not only from her own enormous dominions, but by means of ambassadors from various parts

* 'Lectures on the Science of Language' delivered at the Royal Institution of Great Britain in February, March, April, and May, 1863. Second Series. By Max Müller, Fellow of All Souls College, Oxford; Correspondant de l'Institut de France. London: Longmans, 1864.

'Philological Papers.' By J. A. Picton, F.S.A., President of the Literary and Philosophical Society of Liverpool, 1864. Printed for private circulation only.

of the known world, even from the Indians of North America, specimens of whose languages were procured for her by Washington. In this dictionary 283 words were translated into 51 European and 149 Asiatic languages. The suggestions of Leibnitz gave rise during the last century to other works of a similar character, 'The Catalogue of Languages' by Hervas, and the 'Mithridates' of J. C. Adelung. But that which gave the greatest impetus to the study of Philology was the commencement of the knowledge of Sanskrit in Europe. The first Europeans who acquired any knowledge of this tongue were certain Jesuit missionaries: missionaries have frequently been the first to become acquainted with the speech of uncivilized tribes. Robert de Nobili, in 1606, was the first to acquire a knowledge of this tongue, by adopting the habits, costume, and to a certain extent the religion of the Brahmins. The French missionaries sent by Louis XIV. under Father Pons, in 1697, followed, and their works excited the first curiosity felt in Europe on the subject of the language. The first grammar was published in Rome, in 1790, by Johann Philip Wesclin, better known as Paulinus a Santo Bartolemeo. The early members of the Asiatic Society of Bengal, the great Sir William Jones, Carey, Wilkins, Foster, Colebrooke, and others, studied assiduously the literature of the Brahmins, and published the results of their labours for the benefit of other Europeans.

Frederick Schlegel happened to be in England at the time when Sanskrit first became a subject of general discussion among the learned. With the prophetic insight of the poet, he saw at a glance the wide-spread connection of the languages of the peoples reaching from the Ganges to Iceland, and chronicled his idea in the scarcely yet superseded word—Indo-European. Since then, step by step, the science has gained footing among the learned men of Germany, of England, of France, and of India.

There are several reasons why philology should be studied in England. In the first place there is the mixed nature of our own language; on a groundwork of Saxon phraseology and of Saxon grammar we have grafted what in many cases differs but little from it, a good deal of Norse, much more Norman-French, and in the more scientific subjects Latin and Greek terms in abundance. Again, belonging thus to the Low-German family of tongues, the language from which most of us gain our knowledge of grammar and our first acquaintance with a mode of speech not our own, is the Latin, one of the family of classical tongues. And lastly, our extensive dominions in the East demand on the part of many of our most independent thinkers an acquaintance with the eldest sister of the classical family, *viz.* Sanskrit, an acquirement which, on their return to Europe unconnected with the politics, the science, or the fashion of the day, gives employment to a learned leisure more consonant with its previous employments. Thus philology in England has employed the *horas subsecivas* of many of our quiet thinkers, whilst the increasing demand for genuine classical education, combined with a knowledge of modern languages of the Romance, or High German type, serves to introduce the youth of our time to the principal branches of the Aryan family. The thorough mastery of grammar, moreover, demanded by the Universities paves the way for, and almost demands, some attention for Comparative Grammar. Thus in England lectures on the Science of Language both at Oxford and in London are attended by a large and varied audience; and we have no doubt that Mr. Picton, at Liverpool, received the same attention from the learned societies for his interesting and instructive papers as Professor Max Müller obtained for his deeper and, therefore to the multitude, less interesting communications, written in such English as few Englishmen can hope to attain, and delivered with an accent so slightly foreign as to cause in the hearer envy of such facility in acquiring a strange tongue. The style of the author throughout is so fascinating, so clear, and so well calculated to lead one to admire the subject on which he dilates, that it is with difficulty we refrain from quoting long passages from this work on a subject which most people are wont to think dry and uninteresting. We are sure the extracts we do give will bear out this remark. We can only regret that we must spoil much by abridgment, and we hope we may induce our readers to imbibe more copiously from this "pure well of English undefiled."

The sources whence the science of language expects to receive additions are manifold. The languages of remote and barbarous peoples—for instance, Southern Africa and Polynesia—contribute their share of enlightenment to the missionaries who study them; but nearer home, in the dialects of our own villagers and of our ancestors, the more stay-at-home people may find not only amusement but instruction, and may deduce from what they there find, generalizations that will throw much light on investigations of subjects less well known. Thus the expressions, "He is a-going, I am a-coming," &c., afford the Professor an opportunity for a dissertation of some pages, and a comparison with not only Anglo-Saxon, Gothic, and Old and Modern High German, but also with the distinct dialects of French, Bengali, and Bask. From these comparisons we may find principles that will hold good in the ancient tongues; thus all alike assist in the research; modern forms throw light upon antiquity; *agglutinative* explains *inflectional* formation; whilst the *radical* stage of Chinese and its neighbours explains the earliest condition of the Aryan and Semitic families. The rapid change in the languages of nomadic tribes is seldom sufficiently reckoned. Whilst the antiquity of Man upon this earth is being supported by every possible argument, the yet unbridged gulf between the Aryan and the Semitic families affords a specious argument for an enormous lapse of time between the separation of these peoples and the subdivision of the families themselves. But if this rapid variation of the dialects of nomadic tribes be considered, this period should be greatly shortened if we can trace any analogy whatever between the tongues. In this matter much still remains to be done, yet there are many points of contact that cannot be ignored, and when these are more clearly developed, we think the enormous ages must be somewhat shortened. Professor Müller does not bring forward this argument, but he gives several instances of the peculiar causes which lead to change in unsettled and unwritten tongues, causes which would never occur to our minds were not instances brought under our notice. A remarkable case is as follows:—

"The Tahitians, besides their metaphorical expressions, have another and more singular mode of displaying their reverence towards their king, by a custom which they call *Te pi.* They cease to employ in their common language those words which form a part or the whole of the sovereign's name, or that of one of his near relatives, and invent new terms to supply their place. As all names in Polynesian are significant, and as a chief usually has several, it will be seen that this custom must produce a considerable change in the language. It is true that this change is only temporary, as at the death of king or chief, the new word is dropped and the original term resumed. But it is hardly to be supposed that after one or two generations the old word should still be remembered and reinstated. Anyhow it is a fact that the missionaries, by employing many of the new terms, give them a permanency which will defy the ceremonial loyalty of the natives. Vancouver observes that at the accession of Otu, which took place between the visit of Cook and his own, no less than forty or fifty of the most common words which occur in conversation had been entirely changed. It is not necessary that all the simple words which go to make up a compound name should be changed. The alteration of one is esteemed sufficient: thus in *Po-mare*, signifying "the night (*Po*) of coughing (*mare*)," only the first word *Po* has been dropped, *mi* being used in its place. So in *Ai-mata* (eye eater), the name of the present queen, the *Ai* (eat) has been altered to *amu*, and the *mata* (eye) retained. In *Te-arii-na-vaha-roa* (the chief with a large mouth), *roa* alone has been changed to *maoro*. It is the same as if with the accession of Queen Victoria either the word *victory* had been tabooed altogether, or only part of it, for instance, *tori*, so as to make it high treason to speak during her reign of *Tories*, this word being always supplied by another such, for instance as Liberal Conservative. The object was clearly to guard against the name of the sovereign being ever used, even by accident, in ordinary conversation, and this object is attained by tabooing even one portion of his name." *

Another cause of variation is found more especially among the Kafirs. The women never pronounce any word which contains a sound similar to the names of their male relatives. In many languages the influence of women has given a peculiar turn to the speech of the whole nation. Thus Dante ascribed to the ladies of Italy, who did not understand Latin, the first patronage of literature in the vulgar tongue. Our author goes on to divide many languages into two dialects; "one showing a more manly, the other a more feminine, character." He instances "Greek in its dialects, the Æolic and the Ionic, with their subdivisions the Doric and Ionic;" High and Low German; in Celtic, the Gadhelic and Cymric; in India, the Sanskrit and Prâkrit; and, following the suggestion of Grimm, he believes—

"The stern and strict dialects, the Sanskrit, the Æolic, the Gadhelic, to represent the idiom of the fathers and brothers, used in public assemblies; while the soft and simpler dialects, the Prâkrit, the Ionic, and the Cymric, sprang originally from the domestic idiom of mothers, sisters, and servants at home."

* P. 34.

To this we must demur that whilst the Æolic and Ionic, the High and Low German, the Gadhelic and Cymric were contemporaneous and concurrent, the Prâkrit was a corruption and successor of the Sanskrit; that supposing the Ionian might be considered more polished and more effeminate than the Æolian, the Englishman, the Dutchman, and the Dane have never shown themselves inferior in courage (though they may have been in numbers) to the Prussian or the Austrian. With all respect for Grimm and for Professor Max Müller, we must dissent from a doctrine which is methodical enough to have issued from a French bureau.

With one of the author's conclusions, on which he lays much emphasis, we cannot bring ourselves to agree. He says: "*Without speech no reason, without reason no speech.*" * And again: "We cannot realize general conceptions, or, as they are called by philosophers, nominal essences, such as *animal*, *tree*, *man*, without names; we cannot reason therefore without names or without language." † It may be that in our present condition as civilized beings, having a language on which to rely, we usually do not reason without language. It may be that children before they can speak do not reason, and it may be that the whole logical syllogism cannot be developed without the use of language. But are we in a condition to judge of those who had no language? Did not reason exist in the mind previously to the utterance of language? Do we not even see the glimmerings of reason existing in animals in whom we find no language? Professor Huxley declares that language is the only differentia of man perceptible by the senses; but are we to deny to the whole brute creation that reason which has of late years been able to trace its own image reflected in that darkened glass which indifference and laziness have termed instinct? We might as well say, as many a so-called logician would say, that reasoning could not exist without a syllogism. This is perfectly true in a certain sense. We cannot arrive at certain ends without a certain amount of machinery as a rule, but still we do not know whether we cannot arrive at those ends without the machinery if we have not the ordinary means at hand. All reasoning must be capable of being put into the form of a syllogism, and therefore must be capable of being put into words, but we cannot put ourselves entirely into the position of those who have no words to use, and therefore we cannot tell whether they could not reason without words in such a form as we should be able afterwards to put into words. In one case the author gives an instance against himself. He says—

"The history of religion is in one sense a history of language. Many of the ideas embodied in the language of the Gospel would have been incomprehensible and inexpressible alike, if we imagine that by some miraculous agency they had been communicated to the primitive inhabitants of the earth. Even at the present moment, missionaries find that they have first to educate their savage pupils, that is to say, to raise them to that level of language and thought which had been reached by Greeks, Romans, and Jews, at the beginning of our era, before the words and ideas of Christianity assume any reality to their minds, and before their

* P. 65. † P. 435.

own native language becomes strong enough for the purposes of translation. Words and thoughts here as elsewhere go together; and in one point of view the true history of religion would, as I said, be neither more nor less than an account of the various attempts at expressing the inexpressible."

Here, at least, it is quite clear that the words are entirely wanting because the ideas are unknown, but the idea must first be formed, and the word follows as a matter of course. To take the old metaphor, the shadow *follows* the substance; it is quite true we cannot separate the one from the other; the Peter Schlemihl process is inhuman and monstrous, but the substance is antecedent to the shadow according to all logic. The word ἀγάπη existed before St. Paul's time undoubtedly; here the coming event cast its shadow before; but Christian charity existed in the thoughts and in the life of the Apostle before the Epistle to the Corinthians was penned. Again, many a mathematician sees clearly the whole reasoning of the proposition without going through a word of it; but to put this reasoning into words is a long and laborious process afterwards. A glance at a diagram places the whole train of thought instantaneously before his mind, which it may require hours to reduce to words. The truth of the matter is, Professor Müller has for once been led away by words. Clearly as he is able to see the tendency that words have to cloud the brightest intellect, he has allowed the Greek Logos to confuse his own mind. The collection of instances, the conception and birth of the idea, and the naming, that it may be known by others, are distinct processes. And again, Professor Max Müller instances* a statement of Herodotus, "that the Pelasgians for a long time offered prayer and sacrifice to the gods without having names for them," though he says this "rests on theory rather than fact, yet even as a theory the tradition is curious." Thus a Greek, in spite of his own language (and we know how much the language of Greece and the fanciful derivations of its philosophers influenced their theories), separated the logos spoken from the logos unspoken. Herodotus, who, truthful and honest as he was, was not more clear-headed than Plato and Aristotle, yet could allow a distinction that our great philologist, who usually knows so well the value of words,† mere words, does not see and will not allow.

The second lecture enters into an elaborate account of Bishop Wilkins' proposal for a universal language. The artificial is here plainly distinct from the natural. The next step is to go back as far as investigation will allow towards the origin of language. Here roots, not letters, seem at present to be the "ultimate residuum of complete analysis" of a class of languages. These roots give us all the words with which we are acquainted, but how these roots originated does not at present appear, at least so says the professor. The theory of onomatopœia has been so obstructive to real philological progress, that we cannot be surprised that it is not allowed standing-room in the new science. The bow-wow theory, as Max Müller calls it, receives hard treatment both in these and in the former lectures. Roots must

* P. 435. † P. 560. "They rule the mind, instead of being ruled by it."

have originated in some way; either the sound of the object or the expression of the subject must have been the earliest utterance. It is quite possible that the actual name for a horse, or any other natural object as we at present describe it by its name, may have originated in some particular quality which has been considered striking; but how has that quality received its name? The Lithuanian *aszva* (mare), Latin *equus*, Greek ἵππος (= ἴκκος), and the old Saxon *ehu*, may all have originated in the root *aç*; but whence this root with its signification of swiftness and sharpness? Must it not have arisen from an imitation of the sound of rapid motion; a swift cutting of the air in sunder; a hiss? We do not wish, and we are not able if we wished it, to "undo all the work that has been done by Bopp, Humboldt, Grimm, and others (including not least Max Müller himself), for fifty years," but we think that no one who enters so thoroughly into the subject of tracing language to its origin can with regard to the onomatopœic or imsonic source of roots "remain entirely neutral."

We next proceed to a discussion of the alphabet. After our own language we usually suppose that the alphabet is the thing we know best of all our acquirements. How much there is still to learn even on this subject is best seen from the work under review. We cannot pretend to give an abstract of the author's remarks on this subject, inasmuch as it would require the plates with which he illustrates his text to make the matter plain to our readers. Suffice it to say that he relates the divisions and accounts of letters given by writers of various nations and periods, explains the formation of different sounds as revealed by the laryngoscope (a small looking-glass which enables the experimenter to look down the throat of the patient whilst he speaks), depicts the physiology of pronunciation, and shows how easily one class of sounds may be merged into another. On the exceeding intricacy of this subject he has a passage which we must quote as a specimen of the style and diversity of acquirements of the learned author:—

"After thus taking to pieces the instrument, the tubes and reeds of the human voice, let us now see how that instrument is played by us in speaking or in singing. Familiar and simple as singing or music in general seems to be, it is, if we analyze it, one of the most wonderful phenomena. What we hear when listening to a chorus or a symphony is a commotion of elastic air, of which the wildest sea would give a very inadequate image. The lowest tone which the ear perceives is due to about 30 vibrations in one second, the highest to about 4,000. Consider then what happens in a *Presto*, when thousands of voices and of instruments are simultaneously producing waves of air, each wave crossing the other, not only like the surface waves of the water, but like spherical bodies, and, as it would seem, without any perceptible disturbance. Consider that each tone is accompanied by secondary tones, each instrument has its peculiar *timbre*, due to secondary vibrations; and lastly, let us remember that all this cross-fire of waves, all this whirlpool of sound, is moderated by laws which determine what we call harmony, and by certain traditions or habits which determine what we call melody, both these elements being absent in the songs of birds; that all this must be reflected like a microscopic photograph on the two small organs of hearing, and these excite not only perception, but perception followed by a new feeling even more mysterious, which we call either pleasure or pain, and it will be clear that we are surrounded on all sides by miracles transcending all we are accustomed to call miraculous, and yet disclosing to the genius of an Euler or a Newton laws which admit of the most minute mathematical determination."

Having investigated all the possible letters in an alphabet, we may next examine what portions of the ideal alphabet are possessed by individual languages. Here we find that English and Hindustani, tongues made up of the admixture of several elements, retain and blend the peculiarities of each of their component parts. Thus, while we possess the Gothic *w*, we also have equivalents coming back again through the Norman-French in *gu*, as wise and disguise, wily and guile, &c. Again, *ch* and *j* are Romance or Norman, nevertheless these sounds are introduced into Saxon words, as *choose* (ceósan), *chew* (ceowan), *child* (cild), *cheap* (ceap), *birch*, *finch*, *speech*, *much*, &c.

The Mohawks, the so-called Six Nations, and other natives of North America, have no labials. The Society Islanders have no gutturals, in which the Semitic languages are so strong. Rather unfortunately the first Englishman with whom they became acquainted was one whom they could only call Captain Tute (Cook), a pronunciation that we might match in our nurseries. Dentals exist in every known tongue, though Chinese, Mexicans, Peruvians, Hurons, and several other dialects of both South and North America never pronounce the *d*.

"So perfect a language as Sanskrit has no *f*, no soft sibilants, no short *e* and *o*; Greek has no *y*, no *w*, no *f*, no soft sibilants; Latin likewise has no soft sibilants, no θ, ϕ, χ. English is deficient in guttural breathing, like the German *ach* and *ich*," &c. &c.

Hindustani (admitting Sanskrit, Persian, Arabic, and Turkish words) has 48 consonants; Sanskrit, 37; Turkish, 32; Persian, 31; Arabic, 28; Zulu Kafir, 26, besides clicks; Hebrew, 23; English, 20; Greek, 17, of which 3 are compound; Latin, 17, of which 1 is compound; Mongolian, 17 or 18; Finnish, 11; Polynesian, 10 (no dialect has more—some less); some Australian have 8, with three variations; the Melanesian dialects have 12, 13, 14, and more consonants. Even when the same consonant does occur in two languages, slight shades of difference of pronunciation make it almost impossible to write down the sounds of an unknown tongue. An amusing instance is given of an American gentleman who resided for a long time at Constantinople, but who was sure of the pronunciation of no word in the Turkish language but what he wrote *bactshtasch*, meaning *bakhshish*. *L*, *r* are frequently mistaken, and in Hawaian it is almost impossible to distinguish between *k* and *t*; thus their late king's name is written indifferently Tamehama or Kamehama. Occasionally certain pronunciations are slurred over by certain individuals. Without Professor Max Müller's diagrams most of us know some one who would call *three*, *free*, and have heard *nothing* called *nuffen*.

Many of the changes which have been reduced to rule may be attributed to *phonetic decay*, a most agreeable euphuism for laziness. Laziness leads us to drop some letters, and to slur over the pronunciation of others, combining two into some third sound. Thus, *père* and *mère* are easier to pronounce than *pater* and *mater*; the English *night* is easier than the German *nacht.* The following are specimens of this kind of change :—

A.S. hafoc	becomes	hawk.	*A.S.* nawiht	becomes	nought.
„ dæg	„	day.	„ hlâford	„	lord.
„ fæger	„	fair.	„ hlœfdige	„	lady.
„ secgan	„	say.	„ sœlig	„	silly.
„ sprecan	„	speak.	„ bûton	„	but.
„ folgian	„	follow.	„ heáfod	„	head.
„ morgen	„	morrow.	„ nose-thyrel	„	nostril.
„ cyning	„	king.	„ wîf-man	„	woman.
„ wëorold	„	world.	„ Eofer-wic	„	York.

Again,

Lat. scutarius.	*Fr.* escuier.	*Eng.* squire.
„ historia.	„ histoire.	„ story.
„ Ægyptianus.	„ Egyptian.	„ gipsy.
„ extraneus.	„ estrangier.	„ stranger.
„ hydropsis.		„ dropsy.
„ capitulum.	„ chapître.	„ chapter.
„ dominicella.	„ demoiselle.	„ damsel.
„ paralysis.	„ paralysie.	„ palsy.
„ sacristanus.	„ sacristain.	„ sexton.

From laziness a letter may even be added ; thus it is easier to pronounce—

Eng. thunder	than	*A.S.*	thunor.
Greek ἄνδρες	„		ἄνερες.
„ ἀμβροσία	„		ἀμροσία.
„ μεσημβρία	„		μεσημ(ε)ρία.
Eng. gender	„	*Fr.*	genre.
„ slumber	„	*A.S.*	slumeriar.
„ embers	„	„	æmyrie.
„ cinders	„	*Lat.*	cineres.
„ humble	„	„	humilis.

We now come to the great principle of change called Grimm's law. The author introduces this merely for the sake of explaining what he considers to have been the origin of this diversity. He gives the law, indeed, in all minuteness, and explains the change of every letter, giving an example or two ; but we think it a pity that in the present state of ignorance on these matters amongst the majority of students, there should be no work in the English language to which we could turn for so many examples as would satisfy the seeker after the most perfect induction. We do not say this simply to pick holes, for we are thankful enough for what the author has given, a great deal of which is much newer, and to deep students much more valuable, than the explanation of a known law ; but day after day we find men who profess to be philologists, who have read many works on these subjects, publishing derivations implying most reckless violation of this fundamental change.

And here we must take leave of this interesting and learned work.

There is still much in it on which we have not touched, feeling that it was better to go through carefully the etymological portion, and to leave the mythology possibly for some future opportunity. In this latter subject the author has done much service to a study of the classics, by pointing out that the ancients possessed a religion apart from their mythology; that it was not left entirely for philosophers to speculate on the existence of the gods; but that there was something beyond the sky in which the herdsman and the slave could trust and rely; that this was (Acts xvii. 22, &c.) "the Lord of heaven and earth;" that "they might feel after him and might find him;" and that all men, and not only Jove-born kings and rulers, "are also his offspring." How the layer of superstition was spread thickly over all this deeper feeling is traceable in words—empty words, which men think are their servants, but which are frequently their masters, and which, like all created things, are hard taskmasters when they get the dominion. This mastery of words over men is not confined to the days of heathendom; the legends of the saints, the fairy tales of our youth, the stories of physical wonders in the middle ages, have in many cases their origin in a confusion of thought arising from the similarity of sound between two words entirely distinct and unconnected. This part of the subject we must leave alone, regretting that we cannot follow further through the author's lucid and thoughtful pages, and regretting too that in many cases we have been obliged to put in our own abbreviated form what he has dilated upon with such elegance and fluency of style.

We have left ourselves but little space to speak of the work of Mr. Picton. It is highly creditable to a provincial society that it should be able to elicit such excellent papers from its members. The subject of the Gothic language, important as it is to us if we would understand the roots of our own tongue, is seldom so carefully studied as it evidently has been by our author. A good knowledge of Anglo-Saxon, Gothic, and Norse is becoming every day more important to everyone who would wish to master thoroughly his native English. At the same time it is well to see that the general affinities of the language are studied in its relationship to Sanskrit. We are therefore thankful for the paper on 'Sanskrit Roots.' Of course in this paper we do not discover anything very new. The development of Grimm's law, and the exceptions to it, need to be brought clearly before the general body of English readers. The deeper scholars seem to be too much engaged with their researches to find time to explain and exemplify thoroughly this important principle of philology. We are therefore glad to welcome the exposition of it, and the examples given by Mr. Picton, as likely to be read by many who would be afraid of so large and learned a work as that of Professor Max Müller. In his last paper on 'Architectural Terms' Mr. Picton has done good service to philology, in seeking in the history of his own art for an explanation of the terms used therein. If men of science would thus chronicle what they discover in their researches in their own department, we should not have so many crude guesses or such wild metaphors put forth in the name of veritable etymology.

SPIDERS OF GREAT BRITAIN AND IRELAND.*

It is always a satisfactory consummation when the labour of a lifetime appears before the world, prepared and revised under the immediate supervision of its author; and it is no less a matter of congratulation to see a man who, in the decline of years, has accomplished his work, and lives to enjoy the satisfaction arising from the completion of a laborious task. We therefore congratulate the Natural-History public upon the appearance of the second and concluding portion of this important work, and we congratulate Mr. Blackwall upon the production of the beautifully-illustrated monograph which forms the subject of this notice—a monograph which, for completeness of detail, for care and labour of research, for richness and beauty of illustration, and for zoological interest, may well claim comparison with any with which we are acquainted.

To people in general there is something peculiarly repulsive in the notion of spiders, and their rapacity and ferocity, added to their cunning, and a certain indistinctness of information upon the subject of their poisonous properties, place them under a general ban, such as is shared by the toad and suchlike "ugly and venomous" creatures. And this has probably been the reason why spiders have met with so little attention; so that an investigation of the natural history of the spiders of these islands has opened a field hitherto to all intents and purposes unworked. Indeed, all the Zoologists who have devoted themselves to these really interesting creatures of late years have been Continental observers, particularly those of France, Sweden, and Germany, although one of the earliest Arachnologists was our distinguished countryman, Dr. Martin Lister. Of his treatise, published in 1678, Mr. Blackwall observes, that "in his admirable *Tractatus de Araneis* he has given us a classification of the species he has so ably described, founded on their external organization and economy, which has formed the basis of every subsequent attempt, deserving notice, to effect a systematic arrangement of this interesting order of animals."

The points of interest in the economy and habits of Spiders are numerous, and are likely to receive especial attention from new observers, who will receive an impulse to their studies from the appearance of Mr. Blackwall's admirable monograph. The eyes are taken as a simple and easy basis of classification. On this principle three tribes have been founded, which include all the species hitherto discovered, *viz.* Octonoculina (eyes 8), Senoculina (eyes 6), and Binoculina (eyes 2). Of these the first tribe is by far the most extensive; the second contains ten or eleven genera; while the third has been constituted for the reception of a single genus (Nops), containing two species of extra-European spiders. The head and chest (forming together the cephalo-thorax) are continuous, but the head is easily distinguishable by the presence of the pairs of smooth, simple eyes,

* 'A History of the Spiders of Great Britain and Ireland.' By John Blackwall, F.L.S. Two Parts, 4to. 1861-4. (Ray Society.)

by the *falces*, usually but improperly termed mandibles, which are terminated by a pointed fang, having a ginglymoid movement, and by the oral apparatus. Eight legs of seven joints each, having two or more claws at their extremity, are articulated round the cephalothorax, to which the abdomen, covered with a leathery or horny plate, is united by a short cartilaginous pedicle. Of course the spinning organs claim especial attention, consisting of four, six, or eight mammulæ, situated immediately below the anus, and each composed of one or more joints, from the terminal joint of which five movable papillæ arise, whence issues the viscous secretion of which the silken lines produced by spiders are formed. These are connected with special organs for the formation of this secretion, consisting of intestiniform vessels, having at their base some small supplementary canals. The viscous substance hardens immediately on exposure to the air, forming delicate filaments, which unite to form a common thread.

The falces are used for seizing, killing, and retaining the prey; but a remarkable function is claimed for the palpi. In male spiders, the digital joint of these organs, which are situated on the maxillæ, is commonly short, oval, and dilated, and have the sexual organs (which are thus double) attached within and partially concealed by a cavity on its under side. This view of the nature of the palpi was adopted by Lister, and recent researches, conducted with the utmost caution, have clearly established the accuracy of the opinion. In the females, the palpi are for the most part terminated by a curved pectinated claw.

Spiders change their skins several times before they reach maturity, after each process remaining for a short period in a state of great exhaustion. So also, like Crustacea, they have the power of reproducing detached or mutilated limbs, palpi, or spinners, but only at the period of moulting. Such a mutilated leg may be renewed four or even six times consecutively during the period of immaturity.

The ingeniously-constructed nets or webs which are so familiarly known to all are of several kinds, characterizing different groups of spiders; some of these have not much pretension to elegance of design, but nevertheless well fulfil the purpose of a snare, for which they are intended. The circular geometric nets of the Epëiræ, however, are really wonders of art. An elastic spiral line thickly studded with minute globules of viscid gum, whose circumvolutions are crossed by radii converging to a common centre, and apparently formed of a different material, being unadhesive and very much less elastic. So also the central convolutions are free from the adhesive material, and these form a look-out station from which the spider may keep watch. With regard to the viscidity of the spiral web, light has been thrown upon its nature even since the publication of Mr. Blackwall's work, the first part of which appeared in 1861. He there calculates that the minute globules which stud the lines and give rise to the viscidity are so closely ranged as to give an average of twenty globules upon one-tenth of an inch; and basing upon this calculation, he finds that a large net of *Epëira apoclisa*, 14 or 16 inches in diameter, contains upwards of 120,000 viscid globules, and yet the spider will complete its snare in about forty minutes, if it meet with no interruption. Mr. Richard Beck, in a paper read before the Microscopical Society in 1862, stated that, by examination with a lens of a spider in the act of spinning a geometric web, he had convinced himself that when the thread left the spinnaret no dots were apparent, but that the change was one which took place afterwards and gradually. At first, slightly thicker than ungummed threads, the viscid secretion soon began to form undulations, and eventually separated, forming globules, *by molecular attraction*, at very regular and very minute intervals. It thus appears that a physical law produces the marvellous results formerly attributed to the direct agency of the spider.

It will hardly surprise us to learn that these regular webs are constructed in absolute darkness, without the slightest irregularity of plan or defect of structure; nor that young spiders display in their first attempts the most consummate skill as the most experienced individuals. Nor should the aërial flights of the aëronautic spiders be passed over in silence—excursions which appear to have a migratory instinct as their impulse. These flights are undertaken by the agency of long buoyant threads, which are not *darted* from the spinnarets, and thus propelled to a distance, as was long imagined, but simply ejected gradually, and carried upwards at the same time that they are solidified by the ascending current of air.

To those who are acquainted with the garden-spider, the house-spider, and the *money-spinner*, and whose knowledge of Arachnology, perhaps, then meets with a termination, it will be matter of profound astonishment to hear that the laborious and indefatigable researches of Mr. Blackwall have resulted in the description of upwards of three hundred species of spiders as occurring in Great Britain and Ireland. These are distributed through only thirty-four genera, allowing therefore an unusual number of species to a genus. Indeed, the genus *Linyphia* has thirty-three species; the genus *Epëira*, thirty-one species; *Walcknaera*, thirty-two species; and *Nerienë*, forty-eight. This is a much larger proportion than usually falls to the lot of a well-constituted genus, and probably it will hereafter be found desirable further to subdivide such comprehensive genera; although we do not for a moment call in question Mr. Blackwall's judgment as to this present arrangement. There is another circumstance also which indicates that the practical study of the Arachnology of these islands is in its infancy, and that is the fact that the observers who have co-operated with Mr. Blackwall are so few in number, the chief being two or three gentlemen well known for their attachment to this branch of Zoology, *viz.* Mr. R. H. Meade, Rev. O. Pickard-Cambridge, Rev. Hamlet Clark, and Mr. J. Hardy; while the cabinet of Mr. F. Walker, of the British Museum, has yielded many rare and interesting species; and Mr. R. Templeton has done much for Ireland. As a matter of course, the researches of these gentlemen could be conducted only over a limited extent of country, and the frequent repetitions of the same locality show at once the extreme and praiseworthy industry of these gentlemen, and the great need there is of energetic search in other parts of the country. Of course the vale of Llanrwst has been well scoured by Mr. Blackwall himself, and has yielded a wonderful harvest. Crumpsall, near Manchester, Southport, near Liverpool, and Oakland are localities constantly recurring, from the accidental circumstance that one or other of the above active observers have been located at these spots. The frequent record, too, of a species as having only once been met with proves that more workers only are necessary, not only to elucidate the distribution of spiders over the British islands, but also greatly to increase the list which Mr. Blackwall has already swelled to so large a size.

In concluding this brief notice of a work of great value and importance, we cannot but pay a just tribute to the Ray Society, under whose auspices the work has been produced—a beautifully-printed quarto work of 400 pages. It is magnificently illustrated with twenty-nine plates, containing many hundred figures, for the most part coloured, including a coloured representation of every species, and often two such figures of a species, and numerous interesting details. Such a work could hardly have been undertaken by a private publisher, but by such a subscription society it has been produced in two parts, at one guinea each part to subscribers. There could be no stronger proof of the value of such a combination, and although the second part has been somewhat delayed on account of the plates, we trust that the Ray Society will meet with additional support on account of this transaction. It has passed through some difficulties, but we hope it has seen the end of them, and that under the direction of its present energetic secretary, a long career of usefulness may be before it. Our thanks are due to Mr. Blackwall for his splendid contribution to the Zoology of these islands, and we may congratulate him on their having been so admirably laid before the public, with, as we are told, considerable pecuniary outlay on the part of the author.

POPULAR WORKS ON BOTANY.*

The study of Botany has of late years been much extended, both as regards the curricula of universities and the course of lessons given to the young. Popular works have multiplied,—most of them illustrated by woodcuts, plates, or coloured drawings, which add much to their interest and usefulness. 'Rambles in Search of Wild Flowers,' by Miss Margaret Plues, is a work of this nature. In the introductory portion a description is given, in familiar language, of the various organs of plants; the principles of the natural system of classification are explained; and the classes and sub-classes are defined. The natural orders are then described, and some of the common plants in each are noticed in an instructive manner, illustrated by coloured

* 'Rambles in Search of Wild Flowers, and How to Distinguish them.' By Margaret Plues. London, 1863.

'Rambles in Search of Flowerless Plants.' By the same Authoress. London, 1864.

drawings, which upon the whole are well executed. In the course of the descriptions occasion is taken to notice the various forms of root, stem, leaves, flowers, and fruit; and the youthful readers are led in a very pleasing and attractive way to notice the wild flowers which are strewn around them. Lessons are also given in regard to the plants of Scripture as occasion offers, and the thoughts are directed to the contemplation of the wisdom and goodness of the Creator. In one of the volumes Miss Plues confines her attention to flowering plants, beginning at the Ranunculuses and ending with Grasses. In the other volume she considers the flowerless plants, as Ferns, Mosses, Lichens, Seaweeds, and Fungi. These works cannot fail to be useful to those who wish to enter on the study of native plants, and they are pleasing companions in country rambles.

PAMPHLETS.

On Vitality. By the Rev. H. H. Higgins, M.A.*

Of the various questions which the physiologist is called upon to consider in the course of his researches into the phenomena exhibited by organized beings, none perhaps possesses greater interest than the one discussed in this short but able pamphlet by Mr. Higgins. Is there, or is there not, a force resident in those bodies which, from their special manifestations, we term organisms or living beings, over and above those chemico-physical forces the nature and mode of action of which we recognize and especially study in inorganic bodies? This force has had various terms applied to it by those who affirm its existence, *e. g.* vital force, germ force, vital principle, or vitality, as in the pamphlet before us.

The older physiologists, we may say, universally believed in such a specific organic force, and sought in it an explanation of most of the phenomena to the investigation of which they applied themselves. But the more refined methods of inquiry adopted in recent years have proved that there is no need to presuppose the existence of a specific vital force acting in many of these processes, for they are perfectly explicable by the operation of well-known chemico-physical laws. For it must ever be kept in mind that an organism is a material body, and as such is subjected to the action of those forces which operate in and on matter, though these are undoubtedly modified and often rendered more complicated and difficult to recognize than in inorganic matter. Hence has arisen a physiological school, whose leading members are some of the most brilliant and distinguished of living German physiologists, who, from the results which they have obtained by applying to the investigation of organic processes the methods of chemico-physical

* Read before the Liverpool Literary and Philosophical Society, January 11th, 1864.

research, have been led to deny altogether the existence of any specific vital force. But whilst readily conceding that the advocates for a special vital force have claimed too great a dominion for their favourite potentate, and that many of its supposed subjects are really under the governance of other powers, yet we are by no means inclined entirely to dethrone it. We agree with our author in believing that there is a series of phenomena manifested in organized bodies which cannot be explained by chemico-physical laws, and which is not capable of being recognized even by chemico-physical methods of research.

The broad line of demarcation which separates things animate from things inanimate: the manifestation in the former of those processes which the physiologist distinguishes by the terms development, growth, and maintenance—processes which are exhibited by the simplest vegetable or animal cell as clearly as by the highest and most complicated organism, and which consist not in mere superficial accretions of new matter as in the formation of crystals, the highest of all inorganic forms and processes, but in minute interval molecular changes—points at once to the existence in the former of a specific determining power, no indication of which is met with in the latter.

> "And if life were made up of forces similar to those which act in various ways both on organic and on inorganic matter, we might expect to find the transition from things inanimate to things animate the same in character with all other transactions in nature; the border-land would be occupied with semi-animate materials, and semi-mineral vegetables or animals, with instances of equivocal life and products of doubtful organization. Whereas from the highest to the very lowest organism, the phenomena of life are distinct and unquestionable."

There is a class of scientific observers—pseudo-scientific, we had almost written—who believe that, by passing electrical currents through solutions of albumen or other nitrogenized substances, they can produce in them nuclei, cells, or other well-defined organic forms; and that thus, by the operation of a well-known physical force on certain forms of matter, structures, for whose production the vitalist contends that a special force is necessary, may be generated. But it has never yet been shown that these oval or spherical cell-like forms produced in such solutions are capable of going through those processes of development, growth, and maintenance which are the characteristic phenomena of all living beings. Their morphological similarity has too hastily been assumed to be a proof of their teleological identity. As well might it be said that the arborescent appearance seen on the glass in our window-frames on a frosty winter's morning was the same thing as the trees and other plants whose form and method of branching it simulates.

We have not space to follow Mr. Higgins through the remainder of his carefully reasoned argument that the vital principle is a thing *sui generis*, but in order to give our readers some idea of its nature we reproduce in this place his general summary:—

> "1st. The unparalleled hiatus which exists between things animate and things inanimate.

"2nd. The great dissimilarity between the properties of the imponderables and those of vitality.

"3rd. The difficulty arising from the hypothesis that the embryo of a living thing is developed only by agencies analogous with known forces.

"The permanence of form and structure observable during many generations of the same species.

"5th. The absence of any indications as to what becomes of the vital principle of death.

"6th. The periodicity of life."

Natural History in Jena.*

We have received the second part of the first volume of a new medical and philosophical journal, edited by the Medico-Natural Philosophical Society of Jena. The professors in the small Thuringian University are evidently determined not to be outdone by their brethren in Würzburg, Munich, and other German seats of learning. From the character of the Society under whose auspices the journal appears, the articles have a more many-sided aspect than is possessed by the papers in the well-known 'Zoological Zeitschrift' of Siebold and Kölliker; by the 'Pathological, Physiological, and Practical Medical Archive' of Virchow, or the 'Anatomical and Physiological Archiv' of Müller, now edited by Reichert and Du Bois-Reymond. Accordingly we find in it articles, On Organic Chemistry, by Alsberg, Geuther, Reichardt, and E. Schultze; On Physiology, by Von Bezold; On Anatomy, by Gegenbaur; and on various topics bearing on Practical Medicine and Surgery by Gerhardt, B. S. Schultze, F. Ried, and Schillbach. From the established scientific and practical reputation of several of the above writers we may feel assured that, if the journal is continued in the same spirit with which it has been commenced, it will form a desirable accession to German periodical literature. This blending of the scientific with the practical in the pages of the same publication is not without its advantages, not only to the practitioners of medicine and surgery, but to all men who in the pursuit of their daily bread have to follow out the details of their art without perhaps making much reference to the scientific principles on which it is based. It serves constantly to keep before them the important fact that the two ought never to be dissociated.

We would especially recommend to the notice of our readers the article, On the Influence of the Spinal Cord on the Circulation in the Mammalia, by Von Bezold, the Professor of Physiology in Jena, known as one of the most able of Du Bois-Reymond's pupils, and author of a Memoir on Innervation of the Heart; the paper, On the Episternal Arrangements of the Skeleton in Man and Mammalia, by Gegenbaur; the article, On Acetal, by Alsberg; and the Account of a Case of Resection of the entire Upper Jaw, by Ried.

* 'Jenaische Zeitschrift für Medicin und Naturwissenchaft.' Leipzig. W. Engelmann, 1864.

The Flora of the Carboniferous Epoch of Nova Scotia.*

This author states that he is more and more convinced that no satisfactory progress can be made in fossil botany without studying the plants as they occur in the beds in which they are found, or in large numbers of specimens collected from these beds, so as to ascertain the relation of their parts to each other. A catalogue is given of the plants, with descriptions of some new species. The author comes to the following conclusions:—

1. Of 192 nominal species in the list, probably 44 may be rejected as founded merely on parts of plants, leaving about 148 true species.

2. Of these, on comparison with the list of Unger, Morris, and Lesquereux, 92 seem to be common to Nova Scotia and to Europe, and 59 to Nova Scotia and the United States. Most of these last are common to Europe and the United States. There are 50 species peculiar, in so far as known, to Nova Scotia, though there can be little doubt that several of these will be found elsewhere. It would thus appear that the coal flora of Nova Scotia is more closely allied to that of Europe than to that of the United States. A curious circumstance as connected with a similar relationship of the marine fauna of the period.

3. The greater part of the species have their head-quarters in the middle coal formation; and scarcely any species appear in the upper coal formation that are not also found in the former. The lower coal formation, on the other hand, seems to have a few peculiar species not found at higher levels.

4. The characteristic species of the lower coal formation are *Lepidodendron corrugatum* and *Cyclopteris Acadica*, both of which seem to be widely distributed at or near this horizon in Eastern America, while neither has yet been recognized in the true or middle coal measures. In the upper coal formation *Calamites Suckowii*, *Annŭlaria galioides*, *Sphenophyllum emarginatŭm*, *Cordaites simplex*, *Alethopteris nervosa*, *A. muricata*, *Pecopteris arborescens*, *P. abbreviata*, *P. rigida*, *Neuropteris cordata*, *Dadoxylon materiarum*, *Lepidophlois parvus*, *Sigillaria scutellata* are characteristic plants, though not confined to this group.

5. In the middle coal formation, and in the central part of it, near the greater coal seams, occur the large majority of the species of *Sigillaria*, *Calamites*, *Lepidodendron*, and *Ferns*, some of the species ranging from the millstone-grit into the upper coal formation, while others seem to be more narrowly limited.

* By J. W. Dawson, LL.D., F.R.S., Principal of McGill College, Montreal.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING AT BATH, September, 1864.

The British Association established itself at Bath under circumstances which at once announced to the observer of signs that it was to prove a success. The great influx of members and subscribers, even before the proceedings fairly commenced, enabled the Assistant-Secretary to state to the first general meeting that the numbers were rapidly approaching a maximum, inasmuch as no less than 2,309 had enrolled themselves, thus adding to the exchequer a sum of 2,458*l*. According to the official return, however, the attendance eventually proved less numerous than in 1863 at Newcastle, which may be accounted for by the comparatively lower population of Bath and the neighbourhood. Among the visitors were not a few distinguished in the various walks of science, and although some *habitués* of the Association might have been missed from their places, it would be more easy to say who was not there than to enumerate the *savans* who might be seen assisting at the various Sections. Such a numerous meeting fully proves how popular the Association continues to be, and how eager are the residents of our large towns to avail themselves of the opportunities afforded by the gathering of representative scientific men amongst them, and is a circumstance which may be regarded with satisfaction, as exhibiting a growing appreciation of scientific pursuits. But then great numbers have at the same time their disadvantages. Such a city as Bath, although well provided with edifices adapted for moderate numbers, seldom possesses under one roof space for such a monster assemblage as necessarily assembles at the general meetings of the Association, and the resources of its two most capacious buildings have been severely tried on these occasions. The address of the President, at which all who have arrived endeavour to be present, was delivered in the handsome theatre, which presented a brilliant spectacle, every available spot being crowded from pit to gallery, while upon the stage was assembled around the distinguished speaker the *élite* of the intellectual society of the British Isles. Sir Charles Lyell's enunciation, though low at first, soon gained a distinctness which caused him to be heard in every part of the edifice; his address, to which we devote a separate article, was listened to with marked attention, and when he arrived at that portion of it in which he declared how "fettered we have been by old traditional beliefs," the pent-up interest of the great assembly asserted itself by continued applause.

On the occasions of the *soirées*, the Assembly-rooms have been brought into requisition—apartments well adapted for such a purpose, and connected by historical associations with the palmy days of Bath. This suite of rooms, consisting of ball-room, octagon, and concert-room, was densely crowded by a brilliant company on the second evening of the meeting. The Sections also were extremely well lodged, although it unfortunately happened that they could not all be placed under a single roof. The distance, however, between them was but small, and as soon as the visitor could make himself familiar with their relative position, it was found that they could be reached from one another without much expenditure of time. The Mineral Water Hospital afforded two excellent rooms, in which Section D (Zoology) and Section E (Geography) were located. The latter, much the largest of the two, was however not too large for the numbers which congregated in that popular Section, and was always well filled. Downstairs in the same building, the Sub-section of Physiology, less generally attractive, occupied a modest apartment, where much work, devoid of show, was transacted during the meeting. The Corridor-rooms housed the Chemists (Section B), who could not complain of their location, nor of their audience; though a considerable offshoot of the workers of this Section formed themselves into an unofficial section, under the name of the Pharmaceutical Conference, at which papers bearing on Pharmaceutical Chemistry were read and discussed. The Geologists (Section C) occupied the handsome and spacious Guildhall; the Mathematicians (Section A) found ample space in the Blue-coat School board-room in Sawclose; while the Grammar School in Broad Street housed the essentially-practical philosophers of Section G (Mechanical Science). Perhaps the Statisticians (Section F) were the only division which had any cause for dissatisfaction, the Milsom-street Rooms being inadequate for their requirements; but this was amply remedied after the first day by their removal to the spacious concert-room before mentioned.

The great influx of visitors into Bath has given rise to fabulous tales respecting the exorbitant demands made for their necessary accommodation, but these stories are, we believe, without any foundation in fact. The arrangements made with great care and trouble by the local secretaries would, indeed, suffice to render any attempts at imposition useless, and application to these gentlemen was all that was required to protect the visitor, and to ensure comfortable and reasonable accommodation. A considerable amount of private hospitality was also exercised, nor were the official representatives of the city wanting in recognition of the guests. The Lord-Lieutenant (Earl of Cork) entertained the excursionists to Frome on the Saturday, while the Countess of Waldegrave did the same for those who visited Radstock on the same day. The Mayor of Bath gave a banquet in the Guildhall on Saturday evening to a select assembly, and Mr. Tite, M.P., repeated the entertainment on the following Thursday. The citizens of Bristol also extended their hospitality to that Section of the Association which visited Clifton for the purpose of viewing the beautiful suspension bridge just completed; and many public buildings in Bath have been freely opened to the members of the Association during their stay in the city.

But while the meeting at the beautiful city of Bath will long be remembered as a successful and agreeable one, an unhappy reminiscence must inevitably be associated with it in the melancholy death of Captain Speke, the celebrated African traveller, who met with a fatal accident when shooting in the neighbourhood on the second day of the meeting. As one who had attended the Geographical Section on that very day, and who was to be the hero of a stirring discussion on the following morning, the fatal event caused a sensation in the assembled meeting more easily conceived than described, and necessarily threw a gloom over what in every other respect was a successful and agreeable gathering.

The announcement that the next meeting of the Association, in 1865, will be held at Birmingham, and that Professor Phillips, who, as Sir R. Murchison stated, has been the labouring oar of the Association, is to be its President, will be hailed by the scientific world with satisfaction.

In the following short articles we have endeavoured to place before our readers a few of the leading novelties in science which were brought before the various Sections, and our apology for the imperfection of the record must be the brief space of time at our disposal, little more than a week having intervened between the close of the Association meetings and the issue of this Journal. One of the most important papers, however, recounting the experiments of Mr. William Fairbairn upon the physical properties of submarine cables, will be found amongst our Original Articles, contributed by the author in all its details, and we shall endeavour in our next to atone for our shortcomings in the present number.

The President's Address.

With the modesty which characterizes all truly great men, and which distinguishes, *par excellence*, the President of the British Association, that gentleman confined himself in his Inaugural Address entirely to the branch of science in which he is one of the leading authorities, and in so far he has placed at a manifest disadvantage those of his predecessors (perhaps we are correct in saying all) who ventured to lay before the Association a survey of the progress made in every field of science during the year preceding their installation.

But however gratifying and interesting this new feature may have been to geologists, it is questionable whether it has met with universal approval, and whether it will not by some be regarded with satisfaction rather as an agreeable deviation from an acknowledged custom, than as a precedent to be followed by future presidents.

To many of his hearers, and more especially to his readers, it must have been a source of disappointment not to be favoured with the general survey, which is looked for by the scientific and semi-scientific public. To the Zoologist, for example, it must have been tantalizing to be conducted to the outer courts of his amphitheatre, and instead of being permitted to enter, to be left standing on the threshold whilst his guide started off upon some special, and to him, more urgent business.

It was very unkind of Sir Charles, after having tried the patience of the long-suffering Darwinian (who of all men looks forward to these meetings for an opportunity to improve his experience), whilst he discoursed ably upon the origin and character of the Bath waters, to cut him off with a few sentences concerning the palæontological series, which he said, in confirmation of Mr. Darwin's view, it had never been "part of the plan of nature" to leave perfect "for the enlightenment of rational beings, who might study them in after-ages."

And we must be permitted here to say, by way of parenthesis, with all deference to Mr. Darwin and his illustrious disciple, Sir Charles Lyell, that the conviction has been daily becoming more firmly established in our mind, that it *did* form part of the plan of that Power which moulded nature to leave a sufficiently complete record to enable us rational beings, or rather our posterity, to grasp and comprehend the whole of its operations from the commencement; but we, too, must plead the *present* imperfection of that record as our reason for not discussing the subject.

The Astronomer and the Chemist will equally regret that the President did not favour them with a *résumé* of the progress of their respective branches of science. Spectrum Analysis, the great discovery of the day, was referred to, it is true, but only to inform the world that medicinal hot springs contain Copper, Strontium, and Lithium. What this method of analysis has done during the past twelve months to reveal the composition of the heavenly bodies, or how far it has contributed towards the progress of Chemical Science, are items of information which must be sought elsewhere.

And thus the case stands with the Mechanician, the Ethnologist, the Physicist. All these votaries of science must this year be content to seek a record of novelties in their respective branches elsewhere than in the President's Address. That, restricted as it may have been in its scope, was one of the most valuable contributions to our scientific literature, and it will undoubtedly mark an era in the history of Geological Science.

Nominally it treated of the origin and nature of the mineral waters of Bath; but virtually it dealt with the relation of the phenomena concerned in the production of all hot springs to changes in the level of the land and sea; with glacial action; with the hydro-thermal theory of the formation of crystalline rocks; with volcanic phenomena, &c. It also touched, though very briefly, upon the antiquity of man; upon the inquiry "whether clear evidence can be obtained of a period antecedent to the creation of organic beings upon earth;" and whether the changes which have taken place in the constitution of the earth's crust have been of a comparatively speaking rapid and violent, or of a slow and gradual nature.

Indeed we may repeat that, as a contribution to Geological Science, and a clear exposition of the views of the author and his school, the foremost rank of *savans*, the Address is perhaps without its equal in this branch of our scientific literature.

The following are a few of its salient features, but they in no way convey an adequate idea of the Address, which has been printed in full in most of the leading journals :—

Referring to the past history of Bath, the author touches briefly on the ruins of the ancient city, the Aquæ Solis of the Romans, and speaks of its antiquities and of its relatively lower level as compared with modern Bath.

Its mineral waters next command his attention, and he refers to the fact that there has been no material diminution in their temperature (as is also the case in the waters of Aix, Baden, &c.) since the time of the Romans; and, speculating upon the date of their origin, he expresses the belief that "they are only of high antiquity when contrasted with the brief space of human annals;" for, "though their foundations were tens of thousands of years old, they were laid at an era when the Mediterranean was already inhabited by the same species of marine shells as those with which it is now peopled."

The probable cause of hot springs is, according to Sir Charles, a mighty one; their effect equally potent. From their proportionately greater number and higher temperature as we approach the localities in which there are active or extinct volcanoes, he infers that there is a link between the hot spring and the volcano. And after speaking of the large amount of mineral matter conveyed to the surface by such springs (enough, as Professor Ramsay has estimated in the case of those of Bath, to form a solid square column 9 feet in diameter and 140 feet high), and of the immense quantity of nitrogen gas evolved (according to Dr. Daubeny 250 cubic feet per day), he considers the probable effect of such springs to be that of increasing the bulk of the rocks through which they pass, thus giving rise to a mechanical force of expansion capable of uplifting the incumbent crust of the earth; in fact, he constitutes them one of the causes of change in the relative level of land and water.

The Bath springs, Sir Charles Lyell believes, "like most other thermal waters, mark the site of some great convulsion and fracture which took place in the crust of the earth at some former period." "The uppermost part of the rent through which the hot water rises is situated in horizontal strata of Lias and Trias 300 feet thick," the lower passing "through the inclined and broken strata of the Coal measures."

After describing how the water may have passed downward from the surface, dissolving and retaining mineral matter in its course "until it encounters some mass of heated matter," by which it is converted into steam and driven upwards through a fissure, the author touches upon the analysis of the various mineral waters at home and abroad, attributing some of their virtues to the presence in them of what we may call the spectroscopic metals; namely, those traced by means of the spectroscope—of Lithium, Strontium, Rubidium, &c.; and he speaks of a hot spring discovered near Redruth, in Cornwall, in 1839, at a great depth in a copper mine, in which Professor W. A. Miller has found besides the usual mineral constituents, not only Cæsium, but Lithium, to the extraordinary amount of 1-26th part of its whole solid contents. Sir Charles believes that the efficacy of the new metals for medicinal purposes will probably soon become manifest, and that they will be produced in large quantities and employed in the cure of diseases "which have hitherto baffled human skill."

After noticing some of the phenomena connected with the gradual decrease of temperature in the water as it rises in hot springs and the minerals with which it is charged, he expresses the belief that there is some relationship "between the action of thermal waters and the filling of rents with metallic ores," suggesting that the component elements of the ores may first be held in a state of solution or sublimation in the intensely hot water below, and as this cools be deposited in the fissures.

Another geological phenomenon in which he believes hot springs to play a prominent part is metamorphism, the conversion of deposited strata, many of which once were full of organic remains, into crystalline rocks. Recent experiments and observations have taught geologists that such changes have been the result, not of heat alone, but of heat and water combined, of "hydrothermal" action; that such rocks have been converted, not in the "dry way," which would necessitate an enormous amount of heat, but in the "wet way," "a process requiring a far less intense degree of heat."

Adducing as evidence the experiments of Senarmont, Dobree, Sorby, Sterry Hunt, and other reliable observers, as well as that afforded by the action of thermal springs during the historic period, Sir Charles believes that in the course of ages whole mountain masses may have become thus converted, by means of water permeating through them charged with carbonic and hydrofluoric acids. Whilst, however, he is disposed to substitute for intense heat a longer period of time for the formation of crystalline rocks, Sir Charles still holds that the temperature of the mass below, with which the water is mixed up must be extremely high, and referring to the experiments of Bunsen on the Great Geyser of Iceland, he mentions that at a depth of only 74 feet water in a state of rest possesses a temperature of 248° Fahr.; the temperature then at a depth of a couple of thousand feet is probably intense, as the erupted glowing lava of volcanoes testifies.

To account for this increasing heat as we descend into the earth is at present impossible, or, as Sir Charles observes, "the exact nature of the chemical changes which hydrothermal action may effect in the earth's interior will long remain obscure to us, because the regions where they take place are inaccessible to man; but the manner in which volcanoes have shifted their position throughout a vast series of geological epochs—becoming extinct in one region and breaking out in another—may perhaps explain the increase of heat as we descend towards the interior, without the necessity of our appealing to an original central heat or the igneous fluidity of the earth's nucleus."

Quitting then the subject of hot springs, the President adverts to the changes which, in past ages, have taken place in the land-level of England, and refers to the time when "the Cotswold Hills, at the foot of which this city" (Bath) "is built, formed one of the numerous islands in an archipelago into which England, Ireland, and Scotland were then divided;" and when the sea flowed over Moel Tryfaen, a hill near the Menai Straits, where fossil marine shells have been found at a height of 1,360 feet above the present sea-level.

Passing then to the question of the changes in temperature which must have taken place in England, in common with the whole of central Europe (and speaking chiefly in relation to the Glacial period), he attributes these changes in part to a general alteration in the height of the seas, continents, and mountain ranges; and shows that at one time the Sahara, or great Desert of Africa, must have been under water; the high lands of Barbary, &c., separated from the rest of Africa by a sea; and that there has probably been a connection between Barbary and Southern Europe. The gradual melting away of the Swiss glaciers, Sir Charles attributes to some extent to the Sirocco, or, as the peasants call it, "the Föhn," which hot wind crosses over from Africa; and showing that a cessation of this warm blast, for a brief period only, causes the ice to accumulate perceptibly even in our day, he asks, "What mighty effects we may not imagine the submergence of the Sahara to have produced in adding to the size of Alpine glaciers?" or as Escher* argues, "If the Sahara was a sea in post-tertiary times, we may understand why the Alpine glaciers formerly attained such gigantic dimensions, and why they have left moraines of such magnitude on the plains of Northern Italy and the lower country of Switzerland."

"The more," says Sir Charles, "we study and comprehend the geographical changes of the Glacial period, and the migrations of animals and plants to which it gave rise, the higher our conceptions are raised of the duration of that subdivision of time, which, though vast when measured by the succession of events comprised in it, was brief if estimated by the ordinary rules of geological classification."

It is unnecessary to follow the President through the review which followed, of the story of man's antiquity as it is at present related by Archæologists and Palæontologists; suffice it to say that he traced him through the "Age of Bronze" to the Stone period, when "flint implements" were almost his only weapons, and when his bones lay side by side with the extinct quadrupeds of Europe—the "Elephant, Rhinoceros, Bear, Tiger, and Hyena."

After referring humorously to the reluctance with which some students of Geology bring themselves to consider the long ages that modern science is disposed to attribute to the Glacial and Post-glacial periods, Sir Charles concludes his Address with a few observations upon two questions at present agitating the scientific world: "First, as to whether there has been a continuous succession of events in the organic and inorganic worlds, uninterrupted by violent and general catastrophes; and secondly, whether clear evidence can be obtained of a period antecedent to the creation of organic beings on earth."

In regard to the first point, Sir Charles here speaks with great caution, but we think it may be gathered from his remarks that he considers the "convulsionist" theory to be dying out and giving place

* Escher von der Linth.

to a doctrine in Geology analogous to that of Mr. Darwin in Natural History; with reference to the second, he notices the observations of Dr. Dawson, of Montreal, upon the fossils found in the Laurentian rocks of Canada,* which rocks "are of as old a date as any of the formations named azoic in Europe, if not older, so that they preceded in date rocks once supposed to have been formed before any organic beings had been created:" and Sir Charles expresses the opinion that these observations of Dr. Dawson have demonstrated the theories founded "in Europe on mere negative evidence" to be "altogether delusive." Throughout the whole of this admirable Address Sir Charles seems to have taken especial care, as we think wisely, not to commit himself definitely to any of the numerous theories which at present agitate the Geological world.

In seconding a vote of thanks to the President, Sir Roderick Murchison, who differs from Sir Charles Lyell on some material questions in Geology, nevertheless made a statement which it may be as well to transfer to these pages, as there may perhaps be here and there a few persons who entertain the belief that scientific men are never agreed on any subject which interferes with *their* preconceived views. Such persons will find that, on certain geological doctrines which they bring their minds to consider with great reluctance as being opposed to those of tradition, there is now no difference of opinion whatever. "Let me assure this assembly," said Sir Roderick, "that in all the grand leading *data* on which the history of geology is based we are completely united, and whether it be in recording the regular succession of formations from the oldest to the youngest, the progression from lower to higher types of life, the enormously long periods which must have elapsed in the formation of deposits and their frequent change into crystalline conditions by that metamorphism which he has so skilfully expounded; and lastly, in the evidences he has brought together to show that man must have coexisted with some of the great fossil mammalia. On all these subjects I hold the same opinions as himself; and I have ventured to make this explanation, because it seems to me essential that the public should not run away with the idea that because geologists occasionally disagree on points of theory, that there exists among them any divergence of opinion as to the great foundation stones on which their science has been reared."

Physical Science. (Section A.)

Phillips on the Physical Aspect of the Sun.—Miller and Huggins on the Spectra of the Heavenly Bodies.—Claudet on Photosculpture.

Amongst the large number of papers brought before this Section only a few are of general interest. The greater number are mathematical, and of the physical papers not many will bear the condensation necessary for a report in our pages. We shall therefore omit all reference to such as cannot well be given in abstract.

* 'Quarterly Journal of Science,' vol. i. p. 476.

Some valuable remarks were made by Professor Phillips on the "Physical Aspect of the Sun." In this examination he had been much aided by Cook's Solar Eyepiece, by means of which he was enabled to observe highly luminous bodies. He wished to draw attention to two phenomena—the faculæ and the porosity; he had observed the former as distinctly as the clouds in our own sky. These luminous places were shaded as clouds are with us, and as the Alps appeared at some 50 miles distance. Some of these faculæ were ranges of 40,000 miles long and 40 miles high. With regard to the question of porosity, all that he had observed was an irregular mottled surface between the luminous bands which he had called faculæ, but these markings might be compared to anything, assuming accidental shapes, and formed no definite figure.

On Monday, Dr. Miller, on behalf of himself and Mr. Huggins, read a most interesting paper, "On the Spectra of some of the Heavenly Bodies." The paper directed attention to three leading points, *viz.* facts relating to the planetary spectra, others relative to the spectra of double stars, and some data concerning the spectra of nebulæ. The presence of metals, as evidenced in the case of the light of the planets and some of the heavenly bodies, proved them to be composed of terrestrial substances, whilst the nebulæ were as evidently bodies of gaseous vapour, the character of their light showing that there was no solid matter in them. In the discussion which followed the reading of this paper, Mr. Balfour Stewart said that the remarks on the planetary nebulæ were most important, in showing quite a different constitution of these nebulæ than had been hitherto accepted.

Mr. A. Claudet read a long and valuable paper, "On Photosculpture," the invention of M. Willeme, a French sculptor. This gentleman saw that if he had photographs of many profiles of his sitter taken at the same moment by a number of cameras placed around, he might alternately and consecutively correct his model by comparing the profile outline of each photograph with the corresponding outline of the model. But it soon naturally occurred to him that, instead of correcting his model when nearly completed, he had better work with the pantagraph upon the rough block of clay, and cut it out gradually all round by following one after the other the outline of each of the photographs. Now, supposing he had twenty-four photographs representing the sitter in as many points of view all taken at once, he had but to turn the block of clay after every operation 1-24th round, and to cut out the next profile, and repeat this until the block had completed its entire revolution, and the clay would be transformed into a perfectly solid figure of the twenty-four photographs,—the statue or the bust was made, and only required the finishing touches to be given to it by the artist, who would perform the last operation and would exercise his skill in communicating to the model all the refinement with which, as a sculptor merely, he could have endowed it. Mr. Claudet said, in conclusion, that he thought he could not better illustrate the process of photosculpture than by executing the bust of the President, Sir Charles Lyell. The photographs were taken on the 16th of August;

the machine had done the work; the sculptor had given the finishing touches to the model; and the bust complete, a most striking likeness, was then exhibited to the meeting.

Chemistry. (Section B.)

President's Address.—Daubeny on the Bath Thermal Waters.—Report of the Gun-cotton Committee.—Miller on Wheal Clifford Hot Spring.—King on the Frescoes in the House of Commons.—Calvert on the Extraction of Gold from Auriferous Rocks.—Field on Tin Ore, &c.—Spence on Copper Smelting.—Papers by Herapath, Catton, Paul, Phipson, and Machattie.

The proceedings of the Chemical Section were opened by the President, Dr. Odling, F.R.S., who, in a short but eloquent address, placed before his audience a comprehensive view of the reformation which, within the last dozen years or so, has been effected in the opinions concerning the combining proportions of the elementary bodies and the molecular weights of their most important compounds. The development of the matured views of chemical philosophy which now prevail must, the President said, be traced to Gerhardt's division of volatile bodies into a majority whose recognized molecules corresponded with four volumes of vapour, and a minority whose recognized molecules corresponded respectively with but two volumes of vapour; and from Gerhardt and Laurent's proposal to double the molecular weights of these last, so as to make the molecules of all volatile bodies correspond each with four volumes of vapour. Prior to the time of Gerhardt, the selection of molecular weights for different bodies, elementary and compound, had been almost a matter of hazard. Relying conjointly upon physical and chemical phenomena, he first established definite principles of selection by pointing out the considerations upon which the determination of atomic weights must logically depend. He thus established his classification of the non-metallic elements into—mon-hydrides, represented by chlorine; di-hydrides, represented by oxygen; ter-hydrides, represented by nitrogen; &c.: and relying upon the same principles, later chemists have given to his method a development and unity which have secured for the new system the impregnable and acknowledged position which it at present occupies. Dr. Odling then made a passing allusion to the researches of Professor Kopp on specific heat, and expressed the obligations chemists were under to him for the great additions he had made to this subject; and then proceeded to the oft-debated question of chemical notation. This is at present in anything but a satisfactory state. The sign of addition, so frequently used to express the fine idea of chemical combination, is about the last one would deliberately select for such a purpose. The placing of symbols in contiguity with or without the introduction of a point between them is far preferable; but here, as pointed out by Sir John Herschel, we violate the ordinary algebraic understanding, which assigns very different numerical values to the expressions xy and

$x + y$ respectively. The speaker said that, for some years past, Sir Benjamin Brodie had been engaged in working out a new and strictly philosophical system of chemical notation by means of actual formulæ, instead of mere symbols; and Dr. Odling felt that he only expressed the general wish of the Section when he asked Sir Benjamin Brodie not to postpone the publication of his views for a longer time than was absolutely necessary. It becomes every day more and more important to render the present system of symbolic notation more precise in its meaning and consistent in its application. Many of its incongruities belong to the very lowest order of convention; such, for example, as the custom of distinguishing between the so-called mineral and organic compounds; one particular sequence of symbols being used habitually in representing compounds of carbon, and an entirely different sequence of symbols in representing the more or less analogous compounds of all other elements. It is high time that such relics of the ancient superstition, that organic and mineral chemistry are essentially different from one another, should be done away with. After a brief glance at synthetic chemistry, and isomerism, which was designated the chemical problem of the day, the President concluded by referring to the healthier state of mind in which now perhaps more than ever the first principles of chemical philosophy are explored. Speculation, indeed, is not less rife and scarcely less esteemed than formerly, but it is now seldom or never mistaken for ascertained truth. Scepticism, indeed, still prevails, but it is no longer the barren scepticism of contentment, but the fertile scepticism which aspires to greater and greater certainty of knowledge.

Dr. Daubeny read a most exhaustive paper, "On the Bath Thermal Waters." Under the impression that some of the benefit derived from the use of these waters might be due to the presence of some hitherto undiscovered principle latent in the waters, the lecturer had lately concentrated by evaporation considerable quantities of the water, and tested the residuum, with the view of ascertaining whether, besides the ingredients determined by previous analysts to exist in it, certain other principles might not also be present at least in infinitesimal quantities. He could, however, discover no traces of Fluorine, of Baryta, of Strontia, or of Lithia, although the very delicate method of spectrum analysis was employed to detect their presence. Phosphoric acid and bromine were, however, found to be present. The quantity of gas disengaged from the King's Bath averaged 222 cubic feet in twenty-four hours, and the same phenomenon was observed at least a century and a half ago, showing that the disengagement of gas was by no means a recent occurrence, or one depending on merely adventitious causes. The gas on analysis was found to consist chiefly of nitrogen. If, therefore, the gas emitted were derived from atmospheric air, the latter must have parted with four-fifths of its oxygen before it reached the surface of the earth. This phenomenon is so much the more important, inasmuch as it is common to all natural hot-springs. The lecturer passed in review the different explanations which had been given to account for the origin of this gas, and gave it as his opinion that there was ample reason to infer that the evolution of nitrogen gas when in great excess of the oxygen was essentially connected with that igneous action which is going on in the interior of the earth, and that it was met with in thermal waters only because the latter derived their heat from the same chemical operations which give rise to the phenomena of volcanoes. We are thus compelled to assume that some process of oxidation is going on in the locality, such as should bring about the absorption of the oxygen present in the air which penetrates to these depths. The author then entered into a most interesting discussion as to the cause of thermal springs and volcanoes; the latter phenomena especially resembling those which would occur if water and air were brought into contact with metallic bases possessing a strong affinity for oxygen; and concluded by suggesting that the surplus heat from the springs, which was at present allowed to be wasted in the river, should be utilized by allowing the water to pass through coils of pipes let into the ground a few feet below the surface, so as to communicate its heat to the soil within a given area. With no further expense than this, such an arrangement would secure to the plot of ground placed under the influence of this adventitious temperature a bottom heat sufficient for the growth of early vegetables and for the cultivation of tender exotics; whilst if the waters were in the first instance emptied into a small pond, and afterwards transmitted from thence by means of a coil of pipes gradually embracing a larger circle as they extended, nothing but the protection of an external covering of glass would be required for the cultivation of the gigantic Victoria Regia and other tropical water-lilies; whilst the borders of the pond would at least secure to the inhabitants of Bath the enjoyment of many of the trees and shrubs of warmer countries in the open ground of the garden, and a participation in a genial atmosphere during their most rigorous seasons.

The Gun-cotton Committee laid their second report before the members of this Section. This was merely a formal document relating the circumstances which have taken the matter out of their hands. The Government have appointed a committee to investigate the subject in all its bearings, and have placed on it several members of the British Association Committee. At the close of the report, Professor Abel said that his researches, made on behalf of the Government, were of a satisfactory character, gun-cotton possessing a great superiority over gunpowder both in the simplicity and safety of its manufacture.

Dr. Miller then read a paper, "On the Wheal Clifford Hot Spring, near Redruth, Cornwall," in which he had detected so large a quantity of Lithium that it could not fail to become an economical and abundant source of that rare alkaline metal.

Mr. A. Poole King read a paper, "On the Premature Decay of the Frescoes in the Houses of Parliament," in which he predicted the rapid destruction of these frescoes if the apartment were allowed to remain cold and damp. The moisture would condense in drops on its surface, and be absorbed. These drops would dissolve whatever trace of sulphate of soda existed in the plaster or in the mortar of the wall. The salt would aggregate together, then form ice-like crystals; would leave the plaster, and show itself in a bloom on the surface of the fresco, to be re-dissolved by the first moisture which came over it, and then be re-absorbed again, till at last it would aggregate into blotches, and the destruction would be complete. To preserve the fresco, the author recommended that the robing-room should always be kept dry and warm.

Dr. C. Calvert's paper, "On a New Method of Extracting Gold from Auriferous Rocks," described a method which presented the advantages of not only dispensing with the costly use of mercury, but also of extracting the silver and copper which the ore might contain. The agent employed was nascent chlorine, evolved from a mixture of salt and binoxide of manganese ground up with the auriferous quartz in the proportion of two or three per cent. When sulphuric acid was added the liberated chlorine would attack the gold, and upon allowing water to percolate through the mass it would dissolve out all the gold (as well as the copper and silver), which could then be easily precipitated in the metallic state. This process was said to yield good results, even when working upon a very poor quartz.

Mr. F. Field then described a new ore of tin, and appended to it a few remarks on the state of mineralogy in this country. Referring to the high price and scarcityof bismuth, he said that if search were made in Cornwall there would be no difficulty in getting it; but some persons seemed to have gone fossil mad, and neglected the really valuable minerals, which could be found in almost every county.

These remarks were entirely corroborated by Mr. Salmon and Professor Tenant; and the latter speaker instanced a case in Australia, where a black substance which was at first thrown away in the rush after gold was afterwards found to be tin ore, and was sold for 40*l.* a ton.

An important paper was then read by Mr. Spence, "On Copper Smelting and the Means of Economizing the Sulphur evolved in the Operation." He said he had for many years directed his attention to the subject of economizing the sulphur in copper ores. He had erected furnaces in which small ores could be calcined with little expenditure of fuel and labour, and this enabled him to send all the sulphur so eliminated into the vitriol chambers as sulphurous acid gas. The amount of sulphur wasted in copper-smelting, and which could be economized by the use of such calcining furnaces as he had erected was something enormous. It had been estimated at 70,000 tons per annum, which at the present price of sulphur would be worth 455,000*l.*

A paper by Dr. M. B. Herapath, "On a New Method of Detecting Arsenic, Antimony, Sulphur, and Phosphorus by their Hydrogen Compounds when in Mixed Gases," entering into special analytical details, is of too limited an interest to be transferred to our report, and from the nature of the subject it cannot be given in abstract. The same may be said of Mr. Catton's papers "On the Direct Conversion of

Acetic Acid into Butyric and Caproic Acids," and "On the Molecular Constitution of Carbon Compounds."

These were followed by one by Dr. Paul, "On Paraffin Oil," in which he said that whilst oils lighter than water were quite different from those in gas-tar, the oils heavier than water were very similar, if not identical, with those in gas-tar; and one by Dr. Roscoe, in which he announced that by means of the spectroscope he had detected strontium and lithium in the Bath hot springs in addition to the other well-known constituents.

Dr. Phipson next described some black stones which fell from the atmosphere at Birmingham, in 1858. Analysis showed that they were not aërolites, but small fragments of basaltic rock, similar to that which existed a few leagues from Birmingham. He believed that the stones had been carried to Birmingham by a waterspout. The same author also had a paper, "On the Medicinal Muds of the Island of Ischia." It was in this island and elsewhere customary to plunge the body into muds of this kind as a means of restoring health. They were composed of a volcanic sand, rendered muddy by water and a certain quantity of vegetable *débris*. He had no doubt that the water in its natural state was strongly impregnated with sulphuretted hydrogen, and it was to this agent principally that the medicinal properties were to be ascribed.

A paper by Dr. A. T. Machattie, "On the Detection of Poisons by Dialysis," was next read. This constituted an important contribution to toxicological chemistry, but would be too long to be given at full length in our pages, whilst an abstract would be unintelligible.

One or two other papers of interest will be referred to in the Chemical Chronicle of our next number.

Geology. (Section C.)

Phillips on a Cranium of the Stone Period.—Sanders on Bristol Coal Fields.—Sorby on Metallic Meteorites.—Browne on Ice Caves.—Moore on the Palæontology of Frome.—Stoddart on Geology of Clifton.—Randell on Geology of Bath.—Tristram on Geology of Palestine.

Among the early communications in this Section was one by the President, Professor Phillips, who produced a fragment of a human cranium, taken out *by himself* from the lower strata of one of those singular heaps of accumulated *débris* known on the shores of the Lake of Geneva, laid bare by a railway cutting some time ago, and then described by M. Morlot. In certain parts of this kind of delta, produced on dry land and with great regularity from the annual accession of fresh material, objects were found marking pretty clearly a positive date. Thus, the Roman occupation of Switzerland, which occupied on the whole about 700 years, yielded a few fragments by which it is identified. The bronze period was represented by another group; the period of occupation since the Romans by another; and there is also a stone period earlier than the bronze. This latter is probably contemporaneous with the period of the lake villages, estimated from this source of independent evidence at about 6,500 years old. The fossil was found in this part. There is an element of doubt involved in the absence of certainty as to the limits of the deposit during the Roman occupation of the country.

When this matter was debated, there were several communications bearing on the same subject, and an interesting discussion arose on the antiquity of the human race. The most remarkable feature was the unanimity of the speakers, and the perfect and manifest sympathy exhibited by a very large audience, who kept together in the Section room without flinching from 11 till 4 o'clock. The absence of Dr. Falconer and Mr. Busk, who have just started for Gibraltar, rendered any allusion to the newly-discovered human remains from that quarter undesirable.

Another important communication was the account given by Mr. Sanders of a most admirable and detailed map of the Bristol coal-fields, prepared from parish maps, on a scale of four inches to a mile, independently of the Government survey. In the course of fifteen minutes Mr. Sanders gave an outline of the intelligent and indefatigable labour of a quarter of a century. The manner was worthy of the matter.

Mr. Sorby directed attention to the fact that in metallic meteorites, iron (s. g. 7·8) and olivine (s. g. 3·4) appeared to have been in fusion together, the olivine being left diffused through the iron after cooling. He pointed out that this was impossible on or near the earth's surface, owing to the difference of the specific gravities; and suggested, as an explanation, that the fusion and cooling might either have taken place in the metallic centre of small independent bodies, where the specific gravity was *nil*, the meteorites being fragments of such bodies entering subsequently within the earth's attraction, or that each meteorite had been itself a separate small body cooled in space.

A new and original communication was that of the Rev. G. F. Browne, being an account of several ice-caves or *glacières*, some of them newly discovered, but others already known and described, in Dauphiné, Savoy, and parts of Switzerland. The enormous accumulations of ice, exhibiting in some caves a thickness of 180 feet, the rate of increase of the ice deposit from year to year, the condition and temperature of the ice in summer and winter, and the fact that while some caves at very moderate elevations are full of ice, others apparently under similar conditions and at much greater elevations are free, seem to exclude by turns all the theories that have been suggested. The texture of the cave-ice which occurs in groups of crystals, forming prisms in some parts of the mass, was the subject of a separate communication to the Chemical Section, but complicated the geological problem. It will be necessary to pay greater attention to this curious subject.

Very interesting local communications were made by Mr. Charles Moore and Mr. W. Stoddart. The former alluded to the extraordinary abundance of fossils in the clay near Frome, where more than a million organisms, including 29 mammalian types and many reptilia, were obtained by him from a single cart-load of the material. From the Rhætic beds also Mr. Moore obtained 70,000 teeth of one kind of fossil alone. Mr. Stoddart endeavoured to prove that the dividing line between the Carboniferous and Devonian rocks lies below and not above certain highly-fossiliferous beds at Clifton, which in Ireland have been regarded as Devonian, but are there less rich in fossils. The Marwood sandstone, Coomhola grits, and some other beds, are the Irish representatives, and are largely developed in the south-west of that country. At Clifton, a thin limestone among marls is loaded with incredible numbers of minute organisms, easily separated from the matrix, as the fossils are insoluble in dilute acid, which removes the limestone completely and rapidly. From one pound weight were obtained 1,600,000 perfect fossils, besides fragments and *débris*.

A valuable local memoir was read by Mr. J. Randell on the important beds of building-stone quarried near Bath. The export of these stones from the quarries around Bath exceeds 100,000 tons per annum, and they are conveyed to great distances. Mr. Randell described very accurately their geological position, which he stated to be perfectly definite in the oolitic series. He remarked that the beds occasionally thin out as if lenticular, but they are always under a capping of harder, rougher, and less valuable stone. They die away to the east and south-east. The dip is small, varying generally from one in forty to one in sixty. The thickness of the best stone is from 12 ft. to 25 ft. Above it are 25 to 50 feet of Upper Rag not worked to send away, tough, shelly, and brownish in colour. Below are from 150 to 200 feet of Lower Rag, not always coarse, but apt to decompose on exposure. Mr. Randell then described the method of working in the best quarries. After the first block has been obtained from under the rag, the stone is all sawn, avoiding waste from blasting and wedging. The stone is generally got in the same manner as coal in stalls whose width depends on the goodness of the roof. There is no waste.

A discussion arose on this paper. Professor Phillips alluded to the stone selected by the Romans as having stood better than that now got. Professor Ansted pointed out that the stone, like others, stood much better in a building when it had been first thoroughly dried and hardened in the air. Mr. Ethridge spoke to the accuracy of Mr. Randell's sections.

Mr. Tristram read several interesting communications on the Geology of Palestine and the adjacent parts of Asia Minor. He exhibited fragments of a bone breccia with flint flakes, which Mr. Evans was prepared to assert must certainly have been of human manufacture, and brought from a distance. The age of the breccia was not however clear. Mr. Tristram also exhibited a series of very curious fossils from a limestone of the cretaceous period. Among them were some Ammonites resembling Ceratites, bivalve shells resembling liassic and triassic species of Pholadomya, and others having similar peculiarities. Some of these have lately been found in Africa.

Zoology and Botany. (Section D.)

President's Address.—Galton on Domestication of Animals.—Gibb on the Larynx of the Negro.—Crisp on the Anatomy of the Quadrumana.—Tristram on the Ornithology of Palestine.—Cobbold on Entozoa.—Davy on Salmonidæ.—Buckland on the Oyster.—Lankester on the Earthworm.

In his address, the President, Dr. J. E. Gray, F.R.S., entered in the first place into an inquiry as to the best plan to be pursued to make museums of natural history most useful both to the general public and the scientific student. For the former he considered that a collection of the more interesting objects was required, so as to afford the greatest possible amount of information in a moderate space, and, instead of crowding together a number of specimens of a given genus on the shelves, characteristic specimens should be selected and distinctly labelled, and the purpose for which it was prepared and exhibited should be specified; the economic uses to which it is applied should also be given. For the scientific student he considered that instead of stuffing and mounting the specimens, they could be much more efficiently examined by properly arranging them in drawers and boxes, which would at the same time ensure economy of space.

He then entered into the question of the acclimatization of animals. This term has been employed to express the domestication of wild animals, the introduction of the domestic animals of one country into another, and the cultivation of fishes by the restocking of rivers, ponds, &c., already exhausted. He did not think that any of the wild animals which it was proposed to domesticate could compete in feeding and fattening qualities with our present races of domestic cattle. And though Asiatics have been able to draw largely upon the wild animals around them, yet these are but little suited for our northern climate. He pointed out that it would be advisable to try, in attempting to introduce new domestic animals into our Colonies, if some of the domestic races of Asia or Africa might not be better adapted to their climates than many European breeds. He did not regard very hopefully the attempt to introduce salmon into the Australian rivers, for during a considerable part of each year they are reduced to stagnant pools. The deep rapid rivers of Tasmania he looked on as much more promising. The Acclimatization Society of Australia ought rather to strive for the introduction of the gouramy, or some other edible fish of the countries nearer to and more resembling their own.

A paper of considerable interest was read by Mr. Francis Galton, F.R.S., entitled "First Steps towards the Domestication of Animals."

In it the author contended that the following conditions were required for wild animals to become domesticated. 1st. They should be hardy. 2nd. They should have an inborn liking for man. 3rd. They should be comfort loving. 4th. They should be found useful to the savages. 5th. They should breed freely. 6th. They should be gregarious. The first domestication of animals was due to a vast number of half-unconscious attempts made through the course of ages, and at length, after slow degrees and many relapses, and continued selection, the several domestic breeds now existing became firmly established.

Dr. Gibb read a paper, "On the Larynx of the Negro," in which he stated that the essential point of difference between this organ in the white man and the Negro consisted in the invariable presence of the cartilages of Wrisberg, in the oblique or shelving position of the true vocal cords, and the pendent position of the ventricles of Morgagni in the latter. His observations were based on the examination of the larynx in 500 whites and 58 blacks.

A paper was contributed by Dr. Crisp, "On the Anatomy of the Quadrumana, with a Comparative Estimate of the Intelligence of the Apes and Monkeys." The author in the first place described a method of displaying the comparative anatomy of an animal by means of plaster and wax casts of the most important parts, and showing these alongside of the skeleton and stuffed skin. He then adduced many facts in the anatomy of the Quadrumana, and came to the following conclusions:—1st. That the anthropoid apes, both anatomically and in reference to their amount of intelligence, are not entitled to the elevated position in which they have been placed by some anatomists. 2nd. That the line of demarcation between man and these brutes is so wide and clearly defined as to entitle the human family, as maintained by Blumenbach, Cuvier, and others, to a separate and exclusive division in the animal scale.

The Rev. H. B. Tristram then read a paper, "On the Ornithology of Palestine and the Peculiarities of the Jordan Valley." The author, during a residence there last year, obtained fourteen different kinds of chats, and some birds like the golden plover and the blackwing. Various new species, or new to that locality, were described; amongst these were specimens of the following new and hitherto undescribed species:—The Ceylonese eagle-owl, only hitherto known in South India and China; Gurney's sparrow-hawk, peculiar to Palestine; the Peregrine falcon, on the coast; the Lanner falcon, on the highlands; and the Saker falcon, the largest of all, in the interior; a new species of night-jar, confined exclusively to the Dead Sea; the Galilean swift, confined to the Jordan Valley; the great Alpine swift, and many other species which our limited space will not allow us to name.

Dr. Cobbold, F.R.S., read a paper, "On the Development and Migrations of the Entozoa," in which he related a number of experiments made on the mode of propagation of flukes, tapeworms, round-worms, or their larvæ. He pointed out that the larvæ of the smallest tapeworm yet known were the sole cause of the fatal echinococcus disease of Iceland.

Dr. John Davy read a paper, "On the Salmonidæ, chiefly relating to their Generative Functions." His observations were in part made on the parr of the sea-trout (Salmo trutta), and the object of his inquiry was to ascertain if it, like the parr of the salmon, exercises the generative functions. He concluded that the probabilities were in favour of this view. In the young of the brown trout he has never found the testes more than rudimentary. He does not believe that the sea-trout breeds on its return from the sea into the rivers, as is the case with the salmon, for the ovaries he has examined at this period of the growth of the fish are in little more than a rudimentary state. He thought that with regard to the salmon, sea-trout, common trout, and charr, the evidence was rather in favour of them breeding only in alternate years, or at least not in successive years.

Mr. Frank Buckland, "On the Natural History of the Oyster," in which he related the attempts that had recently been made to promote the artificial cultivation of oysters. He pointed out that this year there had been a failure in the oyster spat, and submitted that the investigation into the cause of this failure was a proper subject of inquiry for scientific men.

Mr. E. R. Lankester read a paper, "On Certain Points in the Anatomy of the Earthworm." The parts to which he directed attention were, firstly, three undescribed pairs of glands connected with the œsophagus; and secondly, the reproductive system. The glands are situated in the twelfth and thirteenth segments of the body. The most anterior pair lie in the twelfth segment; they contain a dense crystalline mass. The two posterior pairs lie in the thirteenth segment; they contain a milky fluid. The author calls them œsophageal glands from their relation to that tube. His observations on the reproductive system coincided almost entirely with those of Dr. Hering, and, in all essential details, with M. d'Udekem.

Physiology. (Sub-section D.)

President's Address.—Turner on Nutrient Arteries for the Lungs.—Foster on Muscular Irritability.—Herapath on Indigo in Pus.—Davy on the Temperature of the Sexes.—Gibb on Action of Bromides of Lithium, Zinc, and Lead.—Hayden on Fat and Sugar as Respiratory Food.—Smith on the Nutritive Principles of Food.

The introductory address by the President, Dr. Edward Smith, F.R.S., consisted of an elaborate and highly interesting report, "On the Present State of the Dietary Question." He reviewed the dietaries of the various prisons, which he considered to stand at present in a very unsatisfactory state; the dietaries of hospitals, schools, and other educational establishments. Referring to "Bantingism," he pointed out that the system of reduction was in numerous cases quite inapplicable.

He then showed that the coarse foods, once so largely employed by the labouring classes, had gone out of use because the labourer had now better wages, the taste was not so agreeable as the finer foods, and they could only be used intermittingly. The nature of the diet employed in various districts of the country was discussed, and the question of the digestibility of food was considered under the various heads of kind, quantity, and conditions under which it acts. An interesting discussion followed, in which Professors Acland and Rolleston, Sir John Richardson, the Bishop of Bath and Wells, and other gentlemen took a part.

"On a Supplementary System of Nutrient Arteries for the Lungs." By Wm. Turner, M.B., F.R.S.E. An arterial plexus was described on the side of the pericardium beneath the mediastinal pleura. It was formed by the junction of the pericardiac, mediastinal, and phrenic branches of the internal mammary artery with each other and with numerous fine branches from the trunks of the intercostal arteries. From it a number of slender thread-like arteries passed to the lung, some in front of its root, others behind, and others between the layers of the ligamentum latum pulmonis. Some of these arteries were distributed in the substance of the lung; others, on its surface beneath the pulmonic pleura. Through the agency of this plexus, an arterial communication is established between the blood vessels of the lung and the arteries which supply the wall of the chest with blood.

Report by Dr. Foster, "On Muscular Irritability." The conclusions drawn from the statements made by numerous experimenters were as follow:—That the urari experiments are inconclusive, because it is not proved that the ultimate nerve branches are affected like the penultimate. That Eckhard's anelectronic experiment is inconclusive, because irritability is by it only lowered, not entirely suspended. That the series of chemical stimuli experiments by Wittich, Kühne, &c., are inconclusive, for the same reason as the urari series; but that the fact that chemical stimulation will take place during the anelectronic effect of the constant current shows, either the contractile tissue is of itself irritable, or that no confidence can be placed in Eckhard's arguments, and that one experiment of Kühne's on that point is almost an experimentum crucis. That, on the whole, the evidence of the above series is decidedly in favour of the existence of muscular irritability. That the experiments and observations of Kühne, Auerbach, and Aeby show that the idio-muscular contractions of Schiff are in reality ordinary contractions in an abortive state and not a special form of contraction; and that the same observations offer connecting links between the oscillatory contractions witnessed by Mr. Bowman, and shown by him to be clearly not due to nervous action, and so afford proof that in a muscular contraction there are two things to be considered — the putting certain molecules in movement, and the communication of that movement from those molecules with greater or less rapidity to all the rest of the fibre; and that since the first movement may commence anywhere, the whole fibre must be called irritable.

"On the Presence of Indigo in Purulent Discharges." Dr. Herapath examined pus presenting a greenish-blue colour. He found that the fluid lost its colour on being corked up in a close bottle, but re-assumed the blue colour on exposure to air. He supposed that this was due to the presence of a colourless material analogous to Indigo and the action of oxygen on it. He obtained crystals from the pus in six-sided plates, and aciculi of a deep-blue colour when sublimed. Other tests were employed which furnished evidence of the presence of Indigo Blue in the pus.

Dr. John Davy, "On the Temperature of the Sexes." Dr. Davy, from observations made in the Tropics and in England, supported the view that the temperature of the male is greater than that of the female.

Dr. G. D. Gibb read a note, "On the Action of the Bromides of Lithium, Zinc, and Lead." The first of these was prepared with the view of treating gout and rheumatism; in small doses it acts as a tonic, gentle stimulant, and sometimes as a diuretic. The Bromide of Zinc relieved impaired nervous power, whilst the Salt of Lead acted as a soothing and cool local agent in some inflamed states of the mucous membrane.

Dr. Hayden read a paper, "On the Relative and Special Applications of Fat and Sugar as Respiratory Food." He believed that fat and sugar possessed different values as food; that they underwent different transformations, during which they subserved distinct purposes of the economy; that the period of their retention in the body is the same; that they are not mutually convertible; but that ultimately they pass out of the body under the common form of carbonic acid and water, and are jointly concerned in the production of animal heat. He considered that fat, being an assimilable substance, can under no circumstances be applied to the maintenance of animal heat before undergoing the twofold process of constructive and destructive assimilation, but that amylo-saccharine substances are immediately and directly passed off from the blood, and are never assimilated in the proper sense of the term. The general conclusions he had arrived at from his experiments were as follows:—The amount of fat deposited in the body is regulated by the absolute and relative quantity of oleaginous and saccharine matter in the food taken; both substances taken in a large quantity, cause excessive deposits of fat. If the fat taken be in defect, even though the sugar be in excess, no increase in the deposit of fat takes place, but rather a decrease, obviously in consequence of ordinary molecular absorption, to which the adipose, in common with other tissues, is subject, not being counterbalanced by assimilation. If the fat taken be in excess, whilst the sugar is insufficient to meet the immediate wants of the respiratory function, still the deposit of fat may not undergo increase, but the contrary, apparently because a portion of that already deposited must undergo reabsorption into the blood for the purpose of supplying heat. Fat is, therefore, as a heat-producing substance, only supplemental of sugar, which is the ordinary *pabulum* of respiration. Saliva, like gastric juice, is secreted in quantity strictly proportioned to the immediate wants of the system, and quite irrespectively of the absolute quantity of food taken; a certain proportion of the starch of the food, varying according to the quantity taken and the necessity of respiration, escapes the converting action of the saliva, and is stored up in the liver. This liver-starch is being taken constantly back into the blood to supplement the respiratory elements of the food, and in the blood is converted into sugar, probably next into lactic, and finally into carbonic acid. Hence the presence of sugar, normally, in small proportion in the blood of the right side of the heart, hence, likewise, its presence in the right side of the heart of animals fed exclusively upon meat, in whose portal blood not a trace of sugar is discoverable.

In three papers Dr. Edward Smith entered into a very elaborate inquiry into the nutritive principles of food; the proportions in which they entered into the different kinds of food; and the most useful combinations of different articles of diet. He showed that there were four methods in use for estimating the nutritive value of food. 1st. The weight of the food. 2nd. The nitrogenous and carboniferous elements in it. 3rd. The nitrogenous food, carbon and hydrogen (reckoned as carbon) in food. 4th. The nitrogen and carbon in food. The mode of determining these he entered into at considerable length. He advocated the desirability of an inquiry into the amount of food which is necessary for the support of the system.

Geography and Ethnology. (Section E.)

Burton on Dahomey—Spruce on the Purus—Bates on the Amazons—Dr. Livingstone's Communications.

Captain Burton made a very interesting and valuable contribution on the subject of the kingdom of Dahomey. His account is totally different from those hitherto given, but it is distinct and positive. He states the population of the country at less than 150,000, of whom not more than one-fifth are men. The accounts of the profusion of human blood shed on festival days he declares to be a wild exaggeration of a peculiar custom—a mark of filial affection—requiring that all events should be communicated to a dead parent by a human being specially sent to the other world. Thus every extraordinary occurrence demands a murder, in order that the king's father may be duly informed. On stated occasions in the year are larger sacrifices. The whole number of victims, however, even on the occasion of these annual festivals, he estimates at from 35 to 40—a number wonderfully smaller than others have told us, but still horrible enough. All these victims are prisoners and guilty of severe crimes, or are prisoners of war. They are stupefied before being put to death, and the execution is performed in the presence of the king and by his chief ministers.*

* Whilst we give Captain Burton's version of the state of affairs in Dahomey, it is right that we should remind our readers of that of Jules Gérard, who visited the king during a "Grand Custom." His account was communicated to 'The Times,' and to these pages (No. I., p. 209), and he appears to think that when

Capt. Burton states that there is a dual king in Dahomey, one for the town and another for the country; and two courts, one male and the other female. The female element is strong in everything. Not only are there Amazonian troops, but to each important person, even including the English strangers, two women are appointed as guards, under the designation of "mother." The women are unusually strong and muscular, and are organized after a very imperfect fashion into troops. Of these there are four corps, distinguished as grenadiers, elephant hunters, razor bearers, archeresses; and there are also troops of the line, who however do not seem so much given to fighting as to dancing, in which all are great proficients. The total strength of this female army does not exceed 2,500, and the fighting members are not 1,700; of whom 1,000 form the king's body-guard. Strangers—Capt. Burton himself included—are appointed to honorary commands in this singular female army.

In conclusion, and after giving many curious accounts of these people, Capt. Burton expressed his firm conviction that the kingdom of Dahomey, once comparatively strong, is now weakening rapidly, and stated that on the occasion of an attack recently made by them on a neighbouring and somewhat more civilized tribe, they were thoroughly defeated and driven back with little difficulty.

Two papers on the Amazons were read—one by Mr. R. Spruce, on the river Purus; the other by Mr. Bates, on the Delta of the Amazons. The Purus connects with the Amazons near the sea, the water occasionally running from the Purus into the Amazons, and at other times from the Amazons into the Purus. The latter is an important navigable river, running through a country almost a dead level. It has numerous lakes. It comes in from the south, and appears to have deep water, so that it may afford a valuable means of communication with the Andes.

The Delta of the Amazons is exceptional. It is neither a mud swamp nor unhealthy, the soil being sandy, with a rocky substratum of calcareous beds, containing fossil marine shells. The climate is pleasant. In the wet season (January to June), the rainfall in 1848 was 61 inches; and in the dry season (the rest of the year), 9½ inches. There are two low islands within the main mouth of the river, and these also are not muddy. Advancing, however, up the river by the Para branch, all signs of ancient land disappear, and the true Delta may be said to commence. Innumerable labyrinthine channels extend for a distance of 80 miles in length and breadth, and the land consists entirely of recent river detritus. Lofty and luxuriant tropical forest covers every part, and overhangs the narrow channels of water which are often not more than 80 yards wide. The climate here is much more humid than below. It results that (owing no doubt to changes

Englishmen are present the black king tries to make things as pleasant as possible, in order that the scenes enacted may be painted, as they have evidently been, *couleur de rose.* Gérard was driven out of Dahomey for his candour, so if the wretched king of this unfortunate people continues his horrible "customs," it is not for want of knowing those of civilized nations, for they evidently take in 'The Times' at Abomey!—*The Editors.*

of level), a great alteration has taken place in comparatively recent times. Mr. Bates concludes that the mouth of the Amazons was not formerly a wide gulf, filled up since by fluvial deposit, but that it was bridged over by a chain of islands, separated by narrower channels than at present. This is illustrated by the fauna and flora.

An interesting memoir was communicated by Mr. James Fox Wilson, on the desiccation of the interior of Southern Africa, by the gradual drying up of large tracts of country in the Bechuana country. In this district the natives are cutting down all the trees, and burning the dried trailing plants, allowing the fires to extend to the mountains. In other parts, the settlers burn the herbage in winter, to have fresh pasture in spring. The effect of this laying bare the surface, is to increase the drought, and the country will become seriously injured by consequent change of climate. It was generally agreed in a discussion which followed the reading of the paper, that in all civilized countries the supply of rain has long been diminishing, and that this is mainly due to agricultural operations.

Dr. Livingstone's and other communications must be deferred; we cannot do them justice here.

Mechanical Science. (Section G.)

Sorby on Photographing the Structure of Metals.—Selwyn and Fairbairn on Submarine Telegraphy.

Mr. Sorby exhibited photographs taken by Mr. Hoole, of Sheffield, under his superintendence, illustrating the condition of iron and steel. The photographs were taken direct from the microscope. The objects are largely magnified, and the results extremely satisfactory. The metal was prepared by Mr. Sorby by acting on a polished surface with weak acid in a way already known, but the result now obtained is quite new and highly instructive. Among other conditions of iron we have: (1) *Meteoric Iron*, exhibiting its crystalline nature in the most perfect manner. (2) *Grey Pig*. Here crystals of graphitic carbon are seen shooting through the mottled surface of the metal. (3) *Refined Cast-iron*. Long lines of hard parts of the metal (probably spiegel-eisen) have arranged themselves in layers. (4) *Slightly-hammered Bloom*. The imperfect and confused state of the iron and slag irregularly mixed are strikingly shown. (5) *Bowling Bar-iron*. In this, the slag being driven off, and the metal rendered more compact, the texture is seen. The result is very curious and valuable, and contrasts singularly with (6) *Swedish Iron*—a steel-like substance, quite as different in texture as in its properties. (7) *Armour-plate* is a curious variety of No. 5. (8) *Blister-steel*. The effect of the converting furnace is very singular and unexpected, and is well seen in this photograph; while (9) *Cast steel* shows the total change produced by an even mottled state of the metal, and the general uniformity of the sections of crystals cut transversely.

No iron-master nor engineer can afford to be ignorant of this simple and effectual mode of determining the structure and texture of the metal he has to do with.

Two papers were read on Submarine Telegraphy—one by Captain Selwyn, R.N., and the other by Mr. Fairbairn, the latter referring to the mechanical properties of telegraphic cables. Captain Selwyn urged that the ordinary cable defended by a spiral wire was weak in principle, as the first strain must be borne by the straight conducting-wire which alone requires defence. He also pointed out that a line to America might take advantage of a shoal in 38° 50′ W. long. in the direct great circle track between England and Bermuda, thus dividing the cable into two sections. Lastly, he recommended that in place of winding the cable as at present, so as to be packed in a ship's hold, it should be wound on one or more closed cylindrical drums acting as floats, and large enough to carry the whole weight. Such cylinders need not be larger than an ordinary canal barge, and could be towed by a steamer, unwound when convenient, and left floating in case of storm. They would be perfectly independent and much cheaper, as well as safer, than the method hitherto adopted. Captain Selwyn proposed for the Atlantic cable a cylinder 120 feet long by 90 feet diameter, which would carry 22,000 tons. The whole weight of the present Atlantic cable is about 6,000 tons.

Mr. Fairbairn's experiments are more fully described at p. 624 of this Journal, than they were before the Association.

NOTES AND CORRESPONDENCE.

Additional Note on the Neanderthal Skull. By Wm. Turner, M.B. (London), F.R.S.E.

In the April number of this Journal I discussed the anatomical characters of the now well-known Neanderthal skull, and advanced a number of examples of modern British crania, which in the extent of their supra-orbital projection, in the retreating nature of their frontal and diminished convexity of their occipital regions, presented forms closely comparable to that of the Neanderthal calvarium. Since the publication of that article I have received a calvarium of a very remarkable form, which may serve as an additional and striking illustration of the occasional appearance in European crania of no great antiquity of characters not unlike those of the skull from the Neander valley. I am indebted for this specimen to the liberality of Dr. Arthur Mitchell, Assistant-Commissioner of Lunacy in Scotland, who informs me "that it was found many years ago, while digging the foundations of Gordon's Hospital in Aberdeen, and that it was regarded, prized, and preserved from its peculiar form, but from the years which have elapsed since it was dug up, from the death of the finder, and the various hands into which it had subsequently passed, it is difficult to trace the exact conditions under which it was found."

I have since ascertained that Gordon's Hospital is built on the site of the Blackfriars Monastery, with which an extensive burial-ground seems to have been connected. It is probable, therefore, that the skull was obtained from a grave in this monastic necropolis. The calvarium is that of a male advanced in years. The sutures are ossified, the denticulations of the sagittal and lambdoidal are quite obliterated. The texture of the bones is very slightly affected; in the posterior part of the skull externally the diplöe is partly exposed; but in the anterior part externally, and the whole of the inner aspect, the surfaces of the two tables are smooth. The animal matter is not removed. The bones are of average thickness.

From the accompanying profile sketch of this calvarium (Fig. 1), on which the outline of the Neanderthal skull has been represented by the dotted line, a comparison of the two may be instituted. The supra-orbital projection, due to the size of the frontal sinuses and the retreating forehead, are both well marked in the one from Aberdeen, though scarcely so pronounced as in the Neanderthal specimen. The vertical diameter is, however, greater, so that the former has not so flattened a form at the vertex as the latter. But in both crania the parieto-occipital regions slope downwards from the vertex, and the posterior parts of the parietal bones form an almost continuous curve with the squamous part of the occipital above the protuberance and superior curved line. And in this its occipital form the Aberdeen skull approaches much more closely to the Neanderthal than does the old Batavian from the Island of Marken, cited by Professor Schaaffhausen, as presenting a great resemblance to it. For as Mr. Huxley has pointed out ('Natural History Review,' July, 1864, p. 439), "if the glabello-occipital lines of the Dutch and Neanderthal specimens be made to coincide, the occiput of the former projects backwards beyond the superior curved

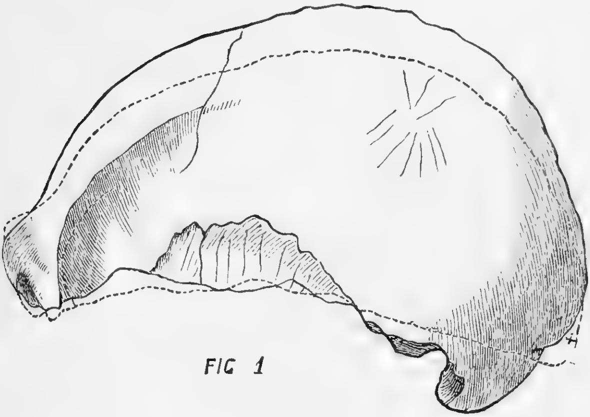


FIG 1

line, whilst that of the Neanderthal slopes upwards and forwards from it."

In the cast of the interior of the Aberdeen calvarium many of the anatomical characters are well displayed (Fig. 2). The comparatively low frontal lobes of the brain, the elevation of the vertex, and the slight posterior convexity of the occipital portion of the cerebrum, are all apparent. It may be noted that the posterior lobes of the cerebrum overlap the posterior margin of the cerebellum, though in the figure the extent of this overlapping is somewhat exaggerated, on account of a Pacchionian body projecting from the dura mater just above the attachment of the tentorium.

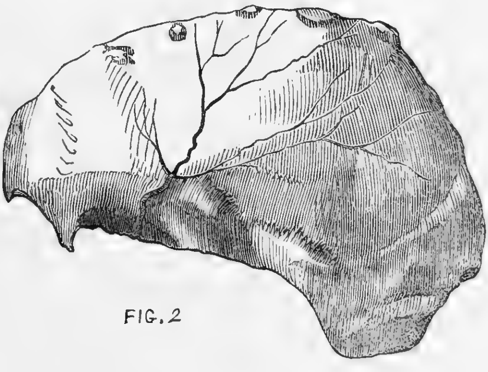


FIG. 2

	Inches.
Greatest length of the Aberdeen skull	7·7
Greatest breadth in the parietal region just above the squamous suture .	5·9
Proportion of length to breadth	100·76
Length of the line of the sagittal suture . . .	4·9
Longitudinal arc . . .	12·6
Horizontal circumference .	22·0
Greatest frontal breadth .	4·5

Capacity of calvarium, 80 cub. in.

In conclusion, I may state that on p. 227 of Sir Wm. Wilde's book, 'On the Beauties of the Boyne and Blackwater,' a skull is figured and described as long and low, which, so far as can be judged from the outline sketch, presents in combination characters which closely approximate it to the Neanderthal cranium. The skeleton of which this skull formed a part was found in 1821, in a gravel-pit in the Island of Funen. Along with it were various metallic articles, a silver buckle, a spirally-twisted gold ring, and a large metal pan or kettle.

Also, in the 'Reader' newspaper, 23rd July, 1864, Mr. Busk states that he has received from Captain Brome, of Gibraltar, a human cranium which resembles, in all essential particulars, including its great thickness, the Neanderthal skull. From the conditions under which it was found, Mr. Busk ascribes enormous antiquity to it.

WM. TURNER.

On the Septa and Siphuncles of Cephalopod Shells. By Harry Seeley, F.G.S., Woodwardian Museum, Cambridge.

THE last generation of anatomists shelved the question of the significance of septa in Nautiloid shells, by assuming that the air-chambers were a beneficent provision for enabling the animals to float. But though the specific gravity of the mass is thus altered, that does not explain the *physiological* meaning of the septa.

As the shells enlarge, the animals increase in size, and, with seldom-varying regularity, shut off behind them chambers which steadily enlarge with the whorls. Only near the end of the series are the cells less uniform, where in the adult the last one is conspicuously shallow. And as the chambers are always empty, the animal must have moved forward, leaving a vacant space behind; so the question to be solved is, why did the creature always make the septa shut off spaces which progressively enlarged?

In certain Gasteropod shells there is something analogous. The genera Murex, Triton, Ranella, for instance, after making their shells uniformly for a third or half of a whorl, then begin thickening the lip into a varix —rarely with the least want of regularity. In other genera, as Bulimus, Conus, Turritella, species or specimens are found with the earlier part of the spire partitioned off. The same phenomena of varices is seen in many bivalves; and a process of shutting off air-cells in the lower valve is characteristic of several oysters.

As the shell of an animal is moulded on its body, I suppose these cells in the abdominal part of an oyster-shell to indicate that the animal gets periodically larger and then smaller. Covering the visceral region are the white parts of the mollusc, the ovaries, and these periodically thicken the body; the lips then in enlarging the shell will make it more concave, and when the ovaries are empty there will remain a vacancy under the ovary like a water-cell, which the abundant nacreous secretion soon shuts off. Moreover, the ovaries are the exterior parts of the organism adjacent to the shell.

In Gasteropods, as the upper part of the spire contains the liver, similar results cannot be looked for in their reproduction; but the ovaries being placed in the middle of the body, and provided with oviducts, often of great size, an enlargement of the whorl must take place by growth at the lip of the mouth till the mollusc attains its full size. And that this is not merely needed to accommodate the body of the animal may, I think, be seen by noticing how far Helices which have laid their eggs retire from the mouths of their shells. And the varices of shells appear to be owing to a cessation of reproductive enlargement in the animal, and hence the mantle accumulates its secretion in a thickening at the lip.

Now, on examining a nautilus-shell, two large muscles are seen to have been placed in the lower part of the body-chamber, and connected round the involute spire by a narrower muscle; an arrangement to which the shell may owe its involute form. Beneath the muscles are the liver which overlaps the spire, the ovaries which abut on a large part of the septum, and certain digestive organs above these. Before any new chamber can be made, the shell-muscles must have moved forward; and before any increase in the ovaries can take place, a space must be formed behind. As the animal steadily grows, all its organs would enlarge, and with each successive brood the distended ovaries would require more space. There is a similar gradual increase in the size of the air-chambers. And since the development of ova would necessitate a forward growth of the mollusc, the discharge of the ovaries would leave an empty space behind, into which the creature could not retire, which would then be shut off by a septum moulded on the animal's body; and it may be worth notice that at the place of the flaccid ovaries, both at the sides and outer part of the shell, the septum extends far forward.

The Argonaut similarly accumulates its eggs in the involute part of the shell, but not being attached to it, does not form septa.

In the male nautilus the testes are placed in exactly the same position as the ovaries of the female, and, excepting the liver, are the largest organ in the body. It may therefore be concluded that the development of the male organs would produce results similar to those in the other sex, and likewise end in the formation of chambers.

There are no other organs of the body which are liable to periodic changes in size; and therefore as the position and progressive enlargement with age of the generative apparatus necessitate results like those seen in the chambers and septa, I regard one as the cause of the other.

If this is the significance of septa in the nautilus, the same must be said of all nautiloid shells, and the families of Ammonites and Orthoceratites; and as the structure of the phragmacone of Belemnites is essentially similar, it must also be applied to such debranchiate shells as are chambered. Among these is the Spirula, connected with a shell essentially like a nautilus shell. Professor Owen describes the greater part of the animal as in front of a shell that is enclosed by a protecting lappet on each side, which is regarded as an ovary. Though this is different from the arrangement in the nautilus there need be no discordancy, for as the animal is not contained within, but overgrows its shell, so ovaries would be expected to extend beyond the rudimentary shell; but from the defect of specimens, I can offer nothing but analogy on behalf of the homology of the two sets of chambers.

In the sepia the ink-bag and ovaries are placed at the end of the animal's body just in front of the mucro of the shell; and in the Belemite the ink-bag is found just above the phragmacone.

Connecting the chambers is the tube known as the *siphuncle* running through every septum to the first, but not through the nidamental capsule. In the nautilus it is often but partly calcified; it changes its position in different genera; and in some fossil-forms, as the sub-genera of Orthoceras, is large and complicated, being sometimes radiated like a coral, and perforated by an inner tube.

Seeing the extreme elasticity of many membranes of invertebrata, as, for instance, the oral membrane of a starfish, I would also point out that when ova were discharged by the nautilus there must have remained the empty membrane, which being attached to the base could not but contract into a tube smaller or larger according to its tenuity or vascularity. The fine siphuncle of the nautilus would indicate a single highly contractile membrane; the large siphuncle of Actinoceras may indicate two or three membranes contracting differently.

And the conclusion from these considerations is that the chief fossil genera of cephalopods are based on slight modifications of the reproductive apparatus, which have produced, in their many beautiful and complex variations, the septa siphuncles of the Nautilus and its allies.

HARRY SEELEY, F.G.S.

On the Existence of the Reindeer and Aurochs in France during the Historic Period. By the Rev. C. W. Kett, M.A.

IN some remarks upon flints and carved bones and horns found in the grottos of Périgord, in the number of 'The Quarterly Journal of Science' for July, p. 579, these implements are stated to prove the existence of the reindeer in the centre of France in *prehistoric* times, and from the carving on them to give the impression that aurochs also existed then in the same country. Your correspondent does not seem to be aware that both these animals existed in *historic* times; that Cæsar describes an animal which has been taken by scholars to represent the reindeer, and that he mentions the aurochs * (*urus*) by name. The description of Cæsar certainly shows that he had never seen these animals, but that he had gathered his information from others; in fact he brings forward this description in a part of his work in which he contrasts what he has heard of the different nations of the Gauls and Germans. I cannot think, however, that this entirely invalidates his testimony, as he appears to have seen the horns and heard of the hunting exploits of the young Gauls of his day. Thinking your readers may be interested in Cæsar's own description, I annex a translation of the two chapters alluded to, 'De Bello Gallico,' lib. vi. cc. 26, 28.

* German *Auer-ochs*, heath or wild ox.

"There is an ox (*bos*) with the form of a stag, and from the middle of its forehead between the ears one horn stands up, higher and straighter than those horns which are known to us. From the end of it branches like palms (*palmæ*) spread out very widely. The male and female are alike, and the shape and size of their horns the same."—CÆSAR: *De Bell. Gall.* lib. vi. c. 26.

"The third is a kind of them which are called aurochs (*uri*). These are of a size little less than elephants; in appearance, colour, and form they are bulls (*tauri*). Their strength is great and so is their pace, and, when they have seen them, they spare neither man nor beast. A good deal of trouble is taken to catch and kill these in pitfalls. In this work the young men harden themselves, and they exercise themselves in this kind of hunting, and those who kill most of them bring their horns as a public testimony, and in this way obtain much honour. Even if they catch them very young, they cannot accustom them to man or make them toward. The size, form, and appearance of their horns differ a good deal from our oxen. They are very careful to tip the lips with silver, and then they use them at their grand feasts."—CÆS.: *De Bell. Gall.* lib. vi. c. 28.

The word *bos*, here translated "ox," is used of all kinds of horned animals, and even for elephants. *Palmæ* has been variously translated, the palms of the hand, the branches of the palm-tree, and the blades of oars. But whatever explanation we put upon these words, the whole description has usually been referred to the reindeer, and has been so understood by Cuvier, Buffon, and Beckman. The single horn, of course, is a mistake, though one that is common enough. Some writers still assert that there is good evidence of the existence of unicorns in the centre of Africa, and although we will not say that such things cannot exist (having the fear of the author of the 'Water Babies' before our eyes), still Cæsar is as likely to have been mistaken in this matter as in the assertion he makes in the following chapter, that the elk cannot bend its legs or get up when once thrown down, whilst he is true as regards the main facts of existence of the animals in France in historic times.

C. W. KETT.

THE GOLD MEDALLISTS OF THE SCIENCE EXAMINATIONS, MAY, 1864, AND SCIENCE INSTRUCTION BY THE STATE.

WE have great pleasure in publishing, as conspicuously as we are able, the names of those Students of the Classes who, to their honour, succeeded in obtaining the Gold Medals at the recent (May) examinations of the Science and Art Department. The names in italics are those of Middle Class Students who obtain Honorary Certificates instead of Medals.

Name of Gold Metallist.	Age.	Residence.	Subject.	Teacher.
JOHN B. BAKER	18	Chester	Geometry, Mechanical Drawing, and Building Construction.	E. A. Davidson.
EDWARD RICHARDS	19	London	Theoretical and Applied Mechanics.	R. Straughan.
JOHN G. ANDERTON	20	Birmingham	Acoustics, Light, Heat, Magnetism, and Electricity.	C. J. Woodward.
John W. Judd	24	*London*	*Ditto ditto*	*Self-taught.*
WILLIAM BARR	19	Glasgow	Inorganic and Organic Chemistry.	Dr. F. Penny.
Alfred H. Allen	18	*Sheffield*	*Ditto ditto*	*Self-taught.*
JOHN CONNOLLY	22	Cork Road, Bandon.	Geology and Mineralogy	Self-taught.
John W. Judd	24	*London*	*Ditto ditto*	*Ditto.*
HENRY ANGEL	20	Islington	Animal Physiology and Zoology.	J. Howard.
ISABELLA MAFFETT	22	Belfast	Vegetable Physiology, Economic and Systematic Botany.	R. Tate.
John W. Judd	24	*London*	*Ditto ditto*	*Self-taught.*
George J. Snelus	26	*Macclesfield*	*Physical Geography*	*— Hewitt.*

The Department of Science and Art also grants Silver and Bronze

"Queen's Medals," (as these rewards are termed,) to successful competitors at the Annual Examinations; but, for the names of these, we must refer our readers to the published Report of the Department.

From the last Report it appears that the number of Science Classes, Teachers, and Students is on the increase, and it was our intention to devote an article in our present number to the question of the extension of Science instruction as it is undertaken by the State—to the relations, in fact, of the Department of Science and Art to the community at large.

The Report has, however, been so recently issued, and so many grave questions are involved, that we must for the present defer the consideration of the subject.

We hope, however, shortly to be able to deal with the matter in an impartial spirit, and all communications which we may receive from Science Teachers, or the promoters of Science Classes in regard to the working of their Schools, or the operation of the various "Minutes" which have from time to time been issued by the Committee of Council on Education, will receive our earnest consideration. Such communications will enable us to arrive at correct conclusions, and to reflect the opinion of a large body of hard-working-men of Science, who, as far as we know, possess no other suitable medium for the expression of their views on matters connected with their material interests.

Books received for Review.

From *Messrs. Longman & Co.*:—

SIGHT AND TOUCH: an Attempt to Disprove the Received (or Berkeleian) Theory of Vision. By Thomas K. Abbott, M.A., Fellow and Tutor of Trinity College, Dublin.

THE LINEN TRADE, Ancient and Modern. By Alex. J. Warden, Merchant, Dundee.

PASSAGES FROM THE LIFE OF A PHILOSOPHER. By Charles Babbage, M.A., F.R.S.

ON THE APPLICATION OF CAST AND WROUGHT IRON TO BUILDING PURPOSES. By William Fairbairn, C.E., F.R.S, F.G.S. 3rd edition. To which is added, A Short Treatise on Wrought-Iron Bridges.

From *Messrs. Trübner & Co.*:—

ORGANIC PHILOSOPHY; or, Man's True Place in Nature. Vol. I. Epicosmology. By Hugh Doherty, M.D.

From *Messrs. Lockwood & Co.*:—

A SERIES OF METRIC TABLES, in which the British Standard Measures and Weights are compared with those of the Metric System at present in use on the Continent. By Charles Hutton Dowling, C.E.

From *Messrs. Simpkin, Marshall, & Co.*:—

GENERAL AND CONCISE HISTORY AND DESCRIPTION OF THE TOWN AND PORT OF KINGSTON-UPON-HULL. By James Joseph Sheahan, Author of Histories of Cambridgeshire, Oxfordshire, &c. &c. &c.

From *the Authors*:—

RAMBLES IN SEARCH OF FLOWERLESS PLANTS. By Margaret Plues. ('Journal of Horticulture' Office; and Houlston & Wright.)

RHOPALOCERA AFRICÆ AUSTRALIS. A Catalogue of South African Butterflies; comprising Descriptions of all the Known Species, with Notices of their Larvæ, Pupæ, Localities, &c. &c. By Roland Trimen, Mem. Ent. Soc. London. Part I. Papilionidæ, Pieridæ, Danaidæ, Acræidæ, and Nymphalidæ. (Cape Town: Mathew, George Street.)

PHILOLOGICAL PAPERS, comprising Notes on the Ancient Gothic Language. Parts I. and II. Sanscrit Roots and English Derivations. By J. A. Picton, F.S.A., President of the Liverpool Literary and Phil. Society. Also, A Chapter on the Philology of Architectural Terms. (Liverpool: Brakell.) (For private distribution only.)

THE STUDY OF THE PHYSICAL SCIENCES: their Value in Education, and the Part they play in advancing the Civilization of Mankind. An Essay. By George D. Wood. (London: F. W. Calder.)

PAMPHLETS, REPRINTS, LECTURES, ADDRESSES, &c.

ON THE MICROSCOPICAL STRUCTURE OF THE MOUNT SORREL SYENITE. By H. C. Sorby, F.R.S., F.G.S.

ON THE CHRONOLOGICAL VALUE OF THE NEW RED SANDSTONE SYSTEM OF DEVONSHIRE. By W. Pengelly, F.R.S., &c.

ELEMENTARY INQUIRY INTO THE LAWS OF THE CONDUCTION OF HEAT ON BARS, AND INTO THE CONDUCTING POWER OF WROUGHT IRON. By James D. Forbes, LL.D., D.C.L., F.R.S., &c.

On Vitality. (Read before the Liverpool Literary and Philosophical Society.) Rev. H. H. Higgins, M.A.

On the Electrical Relations of Metals, &c., in Fused Substances. By G. Gore.

Experiments on the Adhesion of Liquids to Mercury. Same author.

On the Properties of Electro-deposited Antimony. Same author.

Doubts relative to the Epochal and Detrital Theory of Geology. By a near Kinsman of Thomas Didymus. (No publisher.)

The Truth of the Bible Upheld; or, Truth versus Science. By L. S. Benson, South Carolina. (Saunders, Otley, & Co.)

The Abbeville Jaw. An Episode in a Great Controversy. By J. L. Rome, F.G.S. (Longmans.)

A New System of Musical Gymnastics. By M. C. Taylor, M.A., M.C.P. (Tweedie.)

On the Wave of High Water; with Hints towards a New Theory of the Tides. By Thomas Carrick. (Taylor & Francis.)

Mémoire des Professeurs-Administrateurs du Muséum d'Histoire Naturelle, en réponse au Rapport fait en 1858, par une Commission chargée d'étudier l'organisation de cet établissement. (Paris: Mallet-Bachelier.)

Kew and Lisbon Magnetic Curves. Photolithographic impressions of Traces produced simultaneously by the self-recording Magnetographs at Kew and Lisbon. (With explanatory circular.)

L'Hiver dans le Midi: Indications climatologiques et médicales, et Conseils aux Malades. Par A. Buttura, M.D. Paris, &c. &c. &c. (London: Hipp. Baillière.)

The Sanitary Duties of Private Individuals. (The Ladies' Sanitary Association.)

Lumley's Patent Rudder: Descriptive Particulars, &c.

PERIODICALS, AND PROCEEDINGS OF SCIENTIFIC SOCIETIES.

Journal of the Asiatic Society of Bengal. No. 293. (Calcutta.)

Journal of the Chemical Society. (Baillière.)

Bulletin Mensuel de la Société Impériale Zoologique d'Acclimatation. (Paris: Masson.)

Memoirs of the Geological Survey of Great Britain, and of the Museum of Practical Geology. By Robert Hunt, F.R.S., Keeper of the Mining Records. (London: Longmans; and Stanford.)

Transactions of the Woolhope Naturalists' Field Club. President's Address, The Mistletoe, Earthquake of 1863, and Meteorological Report. (Hereford: Head.)

The Geological Magazine (with which is incorporated the 'Geologist'). Edited by T. Rupert Jones, F.G.S., assisted by Henry Woodward, F.G.S., F.L.S.

Revue Universelle des Mines, de la Métallurgie, &c., &c. (Paris & Liège: Noblet & Baudry.)

Jenaische Zeitschrift für Medecin und Naturwissenschaft. (Published by the Natural History Society of Jena.) (Leipzig: Engelmann.)

The Mining and Smelting Magazine. (At the Office, 36, Cannon Street; and Simpkins.)

The British and Foreign Medico-Chirurgical Review. (Churchill & Sons.)

Report of the Superintendent of the United States Coast Survey during the Year 1861. (From the Superintendent.)

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