THURSDAY, OCTOBER 17, 1878

ON THE SCIENCE OF EASY CHAIRS

THERE is a reason for everything, if we can only find it out, but it is sometimes very hard to discover the reasons of even the very simplest things. Every one who has travelled much, and even those who have merely looked through books of travels, must have been struck by the variety of attitudes assumed by the people of different countries. The Hindoo sits down on the ground with his knees drawn up close to his body, so that his chin will almost rest upon them; the Turk squats down cross-legged; the European sits on a chair; while the American often raises his legs to a level with his head. Nor are the postures assumed by the same people under varying circumstances less diverse. Climate or season, for example, will cause considerable alteration in the posture assumed, as was well shown by Alma Tadema, in his pictures of the four seasons exhibited in the Academy a year ago. In his representation of summer he painted a woman leaning backwards on a ledge, with one leg loosely hanging down, while the other was drawn up so that the foot was on a level with the body. In the picture of Winter, on the other hand, we saw a figure with the legs drawn up in front of the belly. The reason for these different postures has been explained by Rosenthal. The temperature of the body, as is well known, is kept up and regulated by the circulation of the blood through it, and a great proportion of the blood contained in the whole body circulates in the vessels of the intestines. Now the intestines are only separated from the external air by the thin abdominal walls, and therefore any change of temperature in the atmosphere will readily act upon them, unless they be guarded by some additional protection. The Hindoos are well aware of this, and they habitually protect the belly by means of a thick shawl or cummerbund, thus guarding themselves against any sudden change of temperature. This precaution is also frequently adopted by Europeans resident in hot climates, and is even retained by them after returning to England. But the function of the cummerbund may, to a certain extent be fulfilled by change of posture alone. When the legs are drawn up, as in the picture of Winter already referred to, the thighs partially cover the abdomen, and taking the place of additional clothing, aid the abdominal walls in protecting the intestines and the blood they contain from the cooling influence of the external air.

Thus it is that in cold weather, when the quantity of covering in bed is insufficient, persons naturally draw up their legs towards the abdomen, so as to retain as much heat as possible before going to sleep. In hot weather, on the contrary, they wish to expose the abdomen as much as possible to the cooling influence of the atmosphere. The posture depicted by Alma Tadema is the most efficient for this purpose. It no doubt answers the purpose to lie down flat on one's back, but in this position the abdominal walls are more or less tight, whereas, when one of the legs is drawn up as in the painting just alluded to, the walls are relaxed, and, the intestines not being subject to any pressure, the blood in them will circulate more rapidly, and the cooling process be carried on more effectually. In this attitude also the thighs are completely separated and loss of heat allowed from their whole surface.

Varying conditions of fatigue also alter the postures which people assume. When slightly tired one is content to sit down in an ordinary chair in the position of the letter N with the middle limb horizontal. As we get more and more fatigued we usually assume positions in which the limbs of the N become more and more oblique, the trunk leaning backwards and the legs extending forwards. If we lie down in bed on our back the legs will probably become straight, but if we rest upon our side they will be more or less bent. The straightness of the legs in the supine position is simply due to their weight, which is then supported at every point by the bed, but when we lie on our sides the genuflexion of the legs is most agreeable, because not only are the muscles more perfectly relaxed, but, as the late Prof. Goodsir pointed out, the bones which form the knee-joint are slightly removed one from another, and thus the joint itself, as well as the muscles, passes into a state of rest. Some of the bamboo easy chairs manufactured in India allow us to obtain the advantages of both positions. These chairs are made in the form of a somewhat irregular straggling W, and in them one can lie on one's back with every part of the body thoroughly supported, and the knees bent in the same way as they would be if one lay upon one's side.

Thus simple inaction, the relaxation of muscles, and the laxity of joints, are some of the factors necessary for complete rest, and an easy chair, to be perfect, must secure them all.

But it is possible for an easy chair to secure all these, and yet be imperfect. We have just said that usually, as the fatigue becomes greater and greater, the tendency is to assume the position of the N with the limbs at a more or less obtuse angle, but when sitting in an ordinary chair we find relief from raising the feet by means of a footstool, although this tends to make the angles of the N more acute instead of more obtuse. Still more relief, however, do we obtain when the legs are raised up on a level with the body by being placed upon another chair, or by being rested on the Indian bamboo seat already described. If, in addition to this, the legs are gently shampooed upwards, the sensation is perfectly delightful, and the feelings of fatigue are greatly lessened. To understand how this can be, it is necessary for us to have some idea as to the cause of fatigue. Any muscular exertion can be performed for a considerable time by a man in average health, without the least feeling of fatigue, but by and by the muscles become weary, and do not respond to the will of their owner so readily as before; and if the exertion be too great, or be continued for too long a time, they will ultimately entirely refuse to perform their functions. The muscle, like a steam-engine, derives the energy which it expends in mechanical work from the combustion going on within it, and this combustion, in both cases, would come to a standstill if its waste products or ashes were not removed. It is these waste products of the muscle which, accumulating within it, cause fatigue, and ultimately paralyse it. This has been very neatly shown by Kronecker, who caused a frog's muscle, separated from the body, to contract until it entirely ceased to respond to a stimulus. He then washed out the waste products from it by means of a little salt and water, and found that its contractile power again returned, just as the power of the steam-engine would be increased by raking the ashes which were blocking up the furnace and putting out the fire. These waste products are partly removed from the muscles by the blood which flows through them, and are carried by the veins into the general circulation. There they undergo more complete combustion, and tend to keep up the temperature of the body. At the same time, however, according to Preyer, they lessen the activity of the nervous system, producing a tendency to sleep, and in this way he would, at least to some extent, explain the agreeable drowsiness which comes on after muscular exertion. It would seem, however, that the circulation of the blood is insufficient to remove all the waste products from the muscles, for we find that they are supplied with a special apparatus for this purpose. Each muscle is generally ensheathed in a thin membrane, or fascia, and besides these we have thicker fasciæ ensheathing whole limbs. These fasciæ act as a pumping apparatus, by which the products of waste may be removed from the muscles which they invest. They consist of two layers, with spaces between. When the muscle is at rest these layers separate and the spaces become filled with fluid derived from the muscle, and when the muscle contracts it presses the two layers of its investing sheath together, and drives out the fluid contained between them. This passes onwards into the lymphatics, where a series of valves prevent its return, and allow it only to move onwards, till at last it is emptied into the general circulation.

In strong and healthy people the veins and lymphatics together are quite able to take up all the fluid which the arteries have supplied to the muscles, and thus prevent any accumulation from taking place either in them or in the cellular tissue adjoining them, or at least prevent any such accumulation as might become evident to the eye. In delicate, weakly persons, or in those who suffer from certain diseases of the vascular system, this is not the case; and after standing or walking for a long time the legs become swollen, so that the boots feel tight, and sometimes even a distinct impression may be remarked at that part of the ankle which was covered by the boot. In such persons we can actually see the swelling disappear, after the feet have been kept rested for some time on a level with the body, and it may be removed more quickly still by gently and steadily rubbing the limbs in one direction from below upwards. It is almost certain that what we thus see in weakly persons occurs to a slighter extent in all, and that even in the most healthy person after a long walk a slight accumulation of fluid, laden with the products of muscular waste, occurs both in the muscles themselves, and in the cellular tissue around them, even although we cannot detect it by simple inspection. So long as the limbs of such a person hang down, the force of gravity retards the return both of blood through the veins and of lymph through the fasciæ and lymphatics, and thus hinders the muscles from getting rid of those waste products which caused the fatigue. When the legs are raised, this hindrance is at once removed, both blood and lymph return more readily from the muscles, carrying with them those substances which had been formed by the muscles of the limbs during the exertions which they had undergone when carrying the body about. So long as these substances remained where they had been formed, they might cause in the muscles of the legs an undue amount of fatigue, although when distributed over the body generally, they may produce only a pleasing languor. When the legs are long, the obstruction to the return of blood and lymph is of course greater than when they are short, and this return will take place more readily when the legs are raised above the body than when they are only on a level with it. This may be one of the reasons why some of our long-legged American cousins are so fond of raising their feet to a level with their heads, or even higher, although it is very probable that there are reasons still more powerful, which we may discuss at a future time.

It has already been mentioned that the lymph is propelled along the interstices of the fasciæ into the lymphatic vessels by the intermittent pressure which the muscle exerts upon them from within, and it seems natural to suppose that the flow may also be aided by a pressure from without, in the form of shampooing. Even when the hand is rubbed backwards and forwards upon the leg it will relieve fatigue, but the relief is greater when the leg is firmly grasped and the hand moved gently upwards so as to drive onwards as much as possible any fluid which may have accumulated in the limb, and the grasp being then relaxed, the same process should be repeated.

But while the lymph is thus most readily removed by the pumping action of intermittent pressure either of the hand without or of the muscles alternately contracting and relaxing within, it seems to us probable that this process may also be aided by steady, constant pressure from without. No doubt it is impossible for such a steady pressure to take the place of the regular pumping action produced by the alternate contraction and relaxation of the muscles when in action, yet it will have a somewhat similar action, though to a very much less extent. For at each beat of the heart, as Mosso shows, the entire limb is distended by the blood driven into the vessels, and during the pauses between the beats it again becomes smaller. Each pulse, therefore, by distending the whole limb and each individual muscle will press out a little of the fluid contained in the fasciæ in the same way as the contractions of the muscles themselves, and it seems to us probable that it is the aid which is afforded to this process by the gentle pressure exerted on the outside of the legs by a seat which supports them along their whole extent, that renders such a seat so peculiarly restful and agreeable. For an easy chair to be perfect, therefore, it ought not only to provide for complete relaxation of the muscles, for flexion and consequent laxity of the joints, but also for the easy return of blood and lymph not merely by the posture of the limbs themselves, but by equable support and pressure against as great a surface of the limbs as possible.

Such are the theoretical demands, and it is interesting to notice how they are all fulfilled by the afore-mentioned chair in the shape of a straggling W, which the languor consequent upon a relaxing climate has taught the natives of India to make, and which is known all over the world.

SCIENTIFIC BALLOONING

Histoire de mes Ascensions. Recit de Vingt-quatre Voyages aériens (1868-1878) *précédé de simples Notions sur les Ballons et la Navigation aérienne.* Par Gaston Tissandier. Illustré de nombreux dessins par Albert Tissandier. (Paris: Dreyfous, 1878.)

M. TISSANDIER has just published a handsome and well-illustrated volume, giving a history of his twenty-four ascents with an account of their scientific results, which are of very considerable importance. M. Tissandier is one of the most scientific of modern aeronauts, and has, by his ascents, made important additions to our knowledge of atmospheric phenomena. The work to which we refer ought to interest many readers; it is not only full of adventures, of "hairbreadth 'scapes," of humorous incidents, and beautiful descriptions of atmospheric scenes, which ought to prove attractive to the general reader, but contains, besides, a large amount of data of great importance in connection with the physics of the air.

Aeronautics, M. Tissandier tells us, may be divided into five distinct branches:—1. The balloon itself. 2. Meteorological aerostation, in the scientific exploration and study of the atmosphere. 3. Military ballooning, captive aerostats, military reconnaissances, the aerial post. 4. Direction of aerostats and aerial navigation. 5. "Aviation," or mechanical flight, the principle of which has been designated under the phase "heavier than air." In the first part of M. Tissandier's work will be found a *résumé* of the principal events in the history of aeronautics, from the first rude attempts down to the magnificent captive balloon of M. Giffard, which has excited so much attention during the Paris Exhibition. The author gives an account of the present state of aerial navigation, and shows what may be expected in the future, judging from facts submitted to the test of scientific reasoning.

The second part of M. Tissandier's work contains an extremely interesting and scientifically valuable account of twenty-four aerial voyages made by himself. It is about ten years since M. Tissandier made his first ascent, and the greater number of his ascents have been made in company with his brother, M. Albert Tissandier, who by the aid of his pencil has recorded the ever new, always interesting, and often incomparable spectacles which the atmosphere opens to the eye of the explorer. Many of his sketches are of great meteorological, as well as artistic, value. In the second part of the work an explanatory diagram indicates exactly the route taken during each journey, the altitude attained, the nature and situation of the clouds, the direction of the currents, their temperature and the atmospheric circumstances connected with them. Numerous wood engravings, from drawings by M. Albert Tissandier, represent the marvellous spectacles observed, the effects of clouds, sunsets, and the various optical phenomena witnessed during the journeys described. Indeed, the work is so luxuriantly got up, and so profusely illustrated, that we are bound to infer either that M. Tissandier's publisher is unusually generous or that France must possess a considerable reading public of more than average intelligence.

The work contains a detailed description of the structure of M. Giffard's monster captive, to the understanding of which the many well-executed illustrations are a great help. An appendix gives the interesting experiments as to carbonic acid in the air made in the *Zenith* by MM. Tissandier and Mangon, and a detailed description of Giffard's new apparatus for the preparation of hydrogen in large quantities.

In a recent lecture at the Sorbonne M. Tissandier endeavoured to point out some of the important services which aeronautics might be made to render to science. A purely theoretical science has necessarily few admirers. It should not be so, however, with the investigation of aerial phenomena. This important department of the physics of the globe is not only useful to the sailors and agriculturists of all nations; it is also of great service in public hygiene. But in order that meteorology, quite a modern science, might be instituted, there should be no doubt of the materiality of the air, thanks to the conceptions of the Galileos, Torricellis, and Pascals. The Meteorological Society of the Palatinate was only founded in 1781; only then were registrations of atmospheric variations begun. The invention of the telegraph soon permitted simultaneous observations to be made, and centralised and led to the hope that prevision of the weather would cease to be an unrealisable chimera. M. Tissandier points out how serviceable to oceanic and river navigation are the warnings transmitted by the International Meteorological Service to the principal maritime stations. The organisation of this service enables us to follow effectively the progress of centres of depression, to discover and announce the general direction of winds, to figure their spirals across space, to establish the curves of the isobaric lines or lines of equal pressure; better still, to prevent, by means of the telegraph, more rapid even than the tempest, a great number of shipwrecks and accidents on coasts.

To discover the real cause of the movements of the air, of cyclones, of the mode of formation, of the direction and variations of the rate of winds, it is necessary, to use the expression of Biot, "prendre la météorologie par en haut," *i.e.*, to seek in the elevated regions of the atmosphere the explanation of the phenomena which occur at the bottom of the aerial ocean where human destinies are accomplished. In fact, "it is in the high regions of the air that meteors are formed, rain, snow, hail; it is there that the lightning traces its furrow, and the thunder rolls; it is there that the aurora borealis displays its plume of light, and that the aerolite shines forth and bursts. There are the upper currents which chariot the clouds. It is to these elevated regions that the science of meteorology ought to be directed."

The observer has the choice between two distinct methods of exploration. He may ascend the mountains or mount in a balloon. No doubt the former process appears at first most secure, but it is seen that the second presents, practically and theoretically, superior advantages, offers most security, and is attended with better results. It suffices to recall the obstacles encountered, the dangers incurred by a tourist guide, the obscure protagonist of the memorable labours of De Saussure, the energetic Jacques Balmat. If he was the first, in August, 1786, to strike his iron-shod staff on the crest of the giant of the Alps, it was only after many fruitful experiments, and after having encountered many perils, and endured much suffering. With the balloon, however, there is less delay, less fatigue: "I launch," said Charles, "into the air like a bird uncaged; in ten minutes I am at a height of 10,000 feet."

If, besides, the aerostatic way is more accessible than the slope of the mountains, it is also preferable from the technical point of view. It is to be remarked, in fact, that the air of high mountains is always subject to the influence of surrounding glaciers. Moreover, these powerful geological reliefs are only formed at certain points of the earth's surface. We must not only climb, but often go far in search of these abrupt and gigantic ladders, while, by means of the balloon, we reach, almost unconsciously, with a rapidity which is prodigious, the laboratory of the principal atmospheric phenomena. M. Tissandier does not deny the utility of observatories like those of the Puy de Dôme and the Pic du Midi, valuable establishments when the services of men like M. Alluard and General de Nansouty can be obtained. The problems of the high regions demand for their solution more than one indefatigable investigator, and, whatever be the mode of investigation followed, the more numerous the workers, the sooner will success crown their efforts.

How many questions are there to solve however! Among the most interesting, and those which are now almost solved, since the researches of M. Tissandier, let us note the presence, in atmospheric dust, of spherules of the magnetic oxide of iron whose diameter scarcely exceeds the 500th part of a millimetre. These spherules, which contain nickel, present a striking analogy of composition with meteoric stones, and have evidently an extra-terrestrial origin. They have been observed in glaciers, in dust-showers like those driven by the wind of the desert; their appearance has been noticed after the explosions of bolides. The sediments left by rain-water present traces of them, and M. Tissandier himself has collected them on the upper steps of the stairs of the tower of Notre-Dôme.

To return to ballooning. Since the discovery of the brothers Montgolfier, since the experiments of Charles, Pilâtre, and the Marquis d'Arlandes, scarcely a century has passed, and yet we can count more than 20,000 ascents. In this number, unfortunately, it would be difficult to find more than 100 undertaken with an exclusively scientific purpose, and with the indispensable instruments of observation.

It was the physicist Robertson who, in 1803, commenced the series of scientific explorations of the air. Biot and Gay Lussac, in 1834, then Gay Lussac alone, accomplished ascents which are important events in meteorological investigation. In 1850 MM. Barral and Bixio made an ascent characterised by very remarkable circumstances. At the height of 7,000 metres they met with a cloud formed, not of vesicles of water, but of spangles of ice. The phenomenon has, moreover, been observed in many other aerial journeys.

M. Tissandier mentions in his book, in a very special manner, the magnificent enterprises of his venerable friend, Mr. James Glaisher, who has made more than thirty aerial voyages, almost always to very great heights. We owe to him observations of great interest, which shed a clear light on many questions, among others on those which refer to the decrease of temperature of humidity in the various strata of air. In later times MM. Camille Flammarion and De Fonvielle have devoted themselves to aeronautics, not without profit to science. Croce-Spinelli and Sivel, also, had made their *début* as masters; their tragic fate, and the miraculous escape of M. Tissandier, our readers must remember. This disastrous journey is fully described in the volume before us.

M. Tissandier endeavours to prove that the direction of the upper atmospheric currents, their rate of translation, their temperature, and their hygrometric state, can only be surely established by means of the aerostat, the observer on the earth being only able to appreciate those elements with reference to superficial winds—simple accidents which ought not to be confounded with the true aerial rivers which often roll their enormous masses above the clouds themselves.

There is room to hope, moreover, that the balloon, which has already received notable improvements, may become, at no distant day perhaps, a directable instrument, and traverse the fields of air as a ship ploughs those of the sea. With these attempts at obtaining control over the course of the balloon, the name of M. Henri Giffard is closely connected. Those who wish to form some idea of what the balloon is capable as an aid to the meteorologist and as a means of investigating the physics of the atmosphere, could not do better than read M. Tissandier's handsome work.

OUR BOOK SHELF

Proceedings of the Aberdeenshire Agricultural Association, 1876-78.

IT has been a subject of frequent regret that while Germany and France have been active in carrying out investigations upon agricultural questions few systematic efforts in this direction have been made in our own country. We learn, therefore, with pleasure that two centres for agricultural investigations have recently been started in Scotland—one by the Aberdeenshire Agricultural Association, the other by the Highland Society. The reports of the Aberdeenshire Association for 1876 and 1877 are now before us, and demand a short notice.

The subject selected for investigation has been the turnip crop, the special object of the experiments being to ascertain the value of various forms of phosphatic and nitrogenous manures. It is impossible not to admire the pains spent on this investigation, but we are sorry to say it is equally evident that the work has been done with very little knowledge of the facts ascertained by earlier investigators of the subject. Labour is consequently spent in proving that which stands in no need of proof, while discoveries are proclaimed of facts already well known to chemists.

One principal point which the experiments are considered to have established is the little superiority of the soluble phosphate of calcium over the insoluble as a manure for turnips. Farmers are told to purchase phosphates in whatever form may be the cheapest, without reference to solubility. This is indeed a startling proposal. Mineral phosphates are at the present day treated with sulphuric acid on a very large scale, with the sole object of producing a superphosphate in which all the phosphoric acid shall be in a soluble form: this mode of treating phosphates is clearly according to the present report an entire mistake. On what experiments is this conclusion based? Will it be believed that in nearly every case the experiment consisted in a comparison of the manuring effect of three parts of phosphoric acid in an insoluble form, with a mixture containing one part of soluble and one part of insoluble phosphoric acid. The result was somewhat in favour of the latter mixture. It will be seen at once that the experiment afforded no fair comparison of the two forms of phosphate. Besides the fatal error of mixing the soluble and insoluble phosphates together, and comparing them in unequal quantities, the amount applied to the land was far too large. Let them drill with one set of turnips 2 or 3 cwts. of superphosphate in which the whole of the phosphoric acid is soluble, and apply to another plot the same amount of phosphoric acid in the so-called insoluble form, and the result of the comparison will be very different to that at present shown.

In speaking of the effect of nitrogenous manures the report correctly states that they produce but little effect on the turnip crop. The fact is that turnips have a greater power than most farm crops of assimilating the nitrogen of the soil, and being thus able to feed themselves stand in little need of artificial help. Where, however, the soil is in an exhausted condition, nitrogenous manures will always produce a marked effect.

The analyses of the turnips grown by the experimental manures supply a variety of "new and unexpected information." Much of this is true in substance, but is already well known to agricultural chemists. We abstain from criticising, for we are sure the next report will show a far better acquaintance with the chemistry of the subject, and that the industry and zeal now displayed will finally issue in real additions to our knowledge of agricultural science.

Euclid. Books I. and II. Edited by W. H. H. Hudson, M.A. *Algebra.* By the Same. (London: The Society for Promoting Christian Knowledge).

THE Euclid is founded on Simson's second edition (1762). In addition to the text there are a few definitions and some judicious explanatory notes. The Algebra (or Primer as the author styles it) is divided into three parts, Part I. Notation, Addition, and Subtraction; Part II. Multiplication, Division, and Simple Equations; Part III. Measures and Multiples, Fractions, and Quadratic Equations. The proof here given of $-a \times -b = ab$, due to Euler, appears to be quite sound. Mr. Hudson states his belief that this proof was misunderstood by Mr. Mill in his criticism ("Logic," vol. ii., ninth edition, p. 408). This little work is an excellent one, and contains a vast amount of good matter in a small compass. Mr. Hudson has performed his task in no perfunctory manner. Both books are brought out with a view to teaching the subjects of which they treat as required by the new code. They are very neatly printed and got up.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

The Magnetic Storm of May 14, 1878

IN regard to the communication on the magnetic storm of May 14, 1878, which appeared in NATURE, vol. xviii. p. 617, it may be interesting to add some particulars furnished by examination of the magnetic photographs of the Royal Observatory.

For some days preceding May 14 the trace of the declination magnet had been very quiet, exhibiting only the ordinary diurnal change; but on May 13, at 18h. 5m., Greenwich mean time, the character of the curve abruptly and distinctly changed, small and frequent oscillations commencing then to be shown. At about 6h. on May 14 the north end of the needle began to move gradually in an easterly direction, and at about 9h. had reached a position twenty-five minutes of arc east of its usual position, the small oscillations still going on. No great change then occurred until 11h. 45m., when the north end of the needle began to move sharply westward. At midnight it had moved twenty minutes westward, occupying then its usual position nearly; almost immediately, however, it turned again eastward, and at 12h. 40m. had moved twenty minutes in that direction; after this time, with the exception of two smaller bends, no other unusual motion occurred, and the magnet gradually resumed its ordinary position. The small oscillations first spoken of ceased at about the time of the commencement of the first rapid motion, at 11h. 45m.

The commencement of the disturbance is not so distinctly perceptible in the trace of the horizontal force magnet, but continued small oscillations occur through the evening of May 14. At 11h. 45m. the northerly force had (gradually since 6h.) decreased nearly 0·01 part of the whole horizontal force; it then increased rapidly, and at midnight had about reached its usual magnitude; by 12h. 40m. it had again considerably diminished (but less than before), and after this time the magnet gradually resumed its usual position. The small oscillations ceased about midnight.

The vertical force magnet trace shows a few very small oscillations during the evening; after 7h. the force decreased gradually till midnight; at the latter time a sharper decrease occurred; at 12h. 30m. the force had altogether diminished by about 0·003 parts of the whole vertical force; after this time the magnet, rather rapidly at first, but afterwards more gradually, returned to its ordinary position.

The first start in the trace of the declination magnet, at 18h. 5m., is most distinct; the character of the trace definitely changes at that time. If the commencement of disturbance is as sharply indicated in the China, Melbourne, and Stonyhurst registers, we shall have here a well-established instance of simultaneous, or nearly simultaneous, action, at widely-separated parts of the earth's surface. The disturbance practically ceased at Greenwich, May 14, 16h. It was comparatively large as occurring in an otherwise quiet year. In years of activity these motions of the magnets, in amount, are, on many days, much exceeded. WILLIAM ELLIS

Royal Observatory, Greenwich, October 12

P.S.—Earth currents were active at Greenwich during the whole period of the magnetic disturbance.

Cyclones and the Winter Gales of Europe

MR. S. A. HILL, in NATURE, vol. xviii. p. 617, compares together the number of hours of high wind in the British Isles with the number of West Indian cyclones observed in each year from 1869 to 1874. It may be interesting to add the result given by the Royal Observatory register. The hourly values of velocity in the years mentioned have not yet been tabulated, but adopting for comparison the number of days on which the daily velocity exceeded 500 miles, we have counted up the number of such days in each year, which numbers, for more ready comparison with those given in NATURE, we have multiplied by a constant. The comparison with the values previously printed in NATURE then stands as follows:—

	1869	1870	1871	1872	1873	1874
Cyclones (W. Indies)	0	7	3	0	1	?
Hours of high wind (British Isles) ...	714	570	537	679	571	658
Days of high wind, Royal Observatory, × 25	975	525	175	725	750	575

WILLIAM ELLIS

Royal Observatory, Greenwich, October 12

Height and Shape of Mount Hekla

I NOTICE that there is a mistake in regard to the height of Hekla in the map which accompanies my account of the eruption of February 27, 1878, for which I fear I am alone responsible. It is there stated to be 4,950 feet. The real height is 4,961 *Danish* feet = 5,108 English feet. The height has been frequently misstated. Sometimes it is asserted to be

5,700 feet, while on the other hand it has been placed as low as 4,300. It is not probable that the height has altered during the last century, for although some writers have asserted that the mountain lost 500 feet during the eruption of 1845, it has been satisfactorily proved that the crater of 1845 opened in the side of the mountain below the principal craters. The previous eruption was in 1772. Hekla is often spoken of as if it were the only volcano in Iceland, while in reality the whole island is dotted over with volcanic vents, of which Hekla is indeed the most frequently active, but by no means the highest. In fact, there are four higher mountains in the island, the highest being Oræfa Jökull—6,426 English feet.

Secondly, as to the shape of Hekla. Volcanoes often present a fairly symmetrical conical form, as we should expect from their mode of formation. This is specially the case in regard to Etna. But Hekla presents rather the appearance of a hog's back. Seen from the north or south it has a long oval outline, serrated by virtue of its three craters, and with an axis which passes from north-east to south-west. Thus the ends of the oval mass alone present the usual conical appearance of volcanoes. It is rather a line of craters than a single one; a volcanic rift elevated above the plain, with large *bocche del fuoco*. These rifts are common in all volcanic countries. In Iceland we have a notable example in Köetlagia, as we commonly call the volcano; in reality *Köetla-gia*—the Köetla rift, along the line of which various vents of fire exist. So again we have Almannagjá, the great rift at Thingvellir. In the eruption of Etna, which took place in 1865, a large rift opened in the side of the mountain, and along the line of it no less than seven small craters opened. In the last eruption of Hekla fourteen small craters opened in a line. We have to distinguish between volcanoes terminated by one large crater, which always furnishes the vent when the eruption takes place from the summit, and volcanoes terminated by a line of craters, one or other of which may be active at any one time. To the former class belong Etna and Vesuvius, to the latter Hekla and Köetla-gjá.

Apparently we cannot get out of the way of spelling Hekla *Hecla*. In one of our leading journals of October 11 I notice the spelling *Hecla*. Hekla means *hooded*, in allusion to the covering of snow, or of cloud, which so frequently rests upon its summit. *Hökull* signifies a chasuble in Icelandic. According to some writers Mount Pilatus, near Lucerne, takes its name from *Pileatus*, in allusion to its cloud-capped summit.

Marlborough College, October 13 G. F. RODWELL

Animal Intelligence

As many of the readers of NATURE have probably not seen my article on the above subject in the current number of the *Nineteenth Century*, I feel it desirable to repeat in these columns the request with which that article concludes. This request is merely that those who read it should favour me by sending to the under-mentioned address brief accounts of any well-marked instances of the display of animal intelligence which may have fallen within their own notice or that of their friends. None of these instances will be published by me without permission; but I desire to accumulate as many of such instances as possible—no matter of how dubious a character—in order that I may obtain a wide basis of suggestion as to the directions in which experiments may be most profitably employed. I may add that as the effect of publishing this invitation in the *Nineteenth Century* has been that of burying my desks in a snow-storm of letters, I should like to take this opportunity of explaining to past and future correspondents that I do not esteem their kindness the less because its bounty is too great for me to acknowledge in individual cases. GEORGE J. ROMANES

18, Cornwall Terrace, Regent's Park, N.W., October 15

The Microphone as a Receiver

I HAVE made some experiments which seem to throw light on the fact mentioned by Prof. Hughes and also by Mr. Blyth (NATURE, vol. xviii. p. 172), that the microphone, or a jar with gas cinders, may act as a receiver.

A Morse-key is set on a sounding-box; one pole of an intermitting current is connected with the lever; the other pole with the fore-part of the key (which for telegraphing purposes is connected with the positive pole of the sending battery). By regulating the screw, which is found at the after-part of the key (which for telegraphing purposes is connected with the coil of the electro-magnet), a slight contact is made between the lever and the fore-part of the key, and directly a very distinct sound is heard of the same character as that of the sound emitted by the interrupting apparatus.

A very good form of the same experiment is the following:—A leaden cylinder and a rocker are taken as used in the experiment of Trevelyan; the rocker is placed on the cylinder, and is, moreover, supported by a sharp edge; if necessary pressure downwards is applied on the stem, in order to prevent the pressure of the rocker on the cylinder being too great. The cylinder is connected with one pole of the intermitting current, the stem of the rocker with the other pole. If the pressure of the rocker on the cylinder be regulated well, a very low sound is produced, specially when the rocker is an iron one. A copper rocker or a copper plate also gives good results. The cylinder was placed on a sounding-box.

An intermitting current sent through the microphone of Prof. Broun (NATURE, vol. xviii. p. 383), as also through a jar with gas cinders, gives a feeble though perfectly audible sound. By using a stronger current, I believe the sound would have been louder. My battery was of four Bunsen cells.

In my opinion the only possible explanation of these facts is the following:—The resistance at the places of contact being relatively very great, a good part of the heat generated by the current appears here, and by dilatations the lever of the Morse-key or the rocker is uplifted. During the interruptions of the current the heat is diffused, and the lever or the rocker falls back, to be again uplifted in the next period of closed current. In this way the lever or the rocker acquires an oscillation of the same period as that of the intermitting current. That a sufficient diffusion of heat in so short a time is possible may be seen from the Trevelyan experiment itself.

My conclusion is that the action of the microphone or of the jar with gas cinders as a receiver depends upon the varying dilatation at the points of contact by the varying intensity of the current. V. A. JULIUS

Breda, Holland, October 12

Power of Stupefying Spiders possessed by Wasps.—Mimicry in Birds

MR. CECIL's remarks on the spider-hunting wasp (NATURE, vol. xvii. p. 381) have interested me greatly, these wasps being very common here. Two species are continually hovering about the wall-plates and eaves of my house in search of their prey, which they hunt out with most praiseworthy perseverance. Both are thin-bodied, but one is half as long again and has a larger body, as also broader black rings than the other. A few remarks may be of interest to your readers.

These wasps build variously-shaped mud nests, which are met with hanging from twigs in the bush or stuck on walls in houses and under overhanging rocks. Some species use a red sandy loam, others common mud.

The nest is divided into compartments, each of which contains an ovum, and is filled with spiders, on which the larvæ feed.

For a long time I was under the impression that these spiders were killed outright, and was puzzled to find them perfectly fresh and juicy after a lapse of a fortnight, with a thermometer ranging up to 118° in the shade; but a few days ago I broke open a large nest, and was astonished to notice a constant movement in the legs of half-a-dozen spiders which were contained in one cell.

I have since then examined several nests, and invariably with the same result.

Mrs. Hubbard's explanation of the tracking described by Mr. Cecil (NATURE, vol. xvii. p. 402) is no doubt correct as far as it goes, but the wasps here seem to "go in" for every and all species of spiders, with only one exception.

My house abounds with a podgy black spider having a bright vermilion patch on the medial line of the body and two bright spots above this patch. This insect is a most venomous and dangerous neighbour; its bite is highly poisonous and inflicts excruciating agony on the person or animal bitten. I have seen a terrier succumb to its effects in eight hours, and one young man went mad in 1868 from the effects of a bite received in the wrist. Several persons have been bitten here during the last two years, and only the immediate use of ammonia and spirits saved them from serious injury. This spider is carefully avoided by the wasp, who immediately retreats on discovering that the occupant of a web belongs to this species.

Several small hunting spiders are to be found in the wasps nests which do not seem to leave any line behind them, and whose mode of life is very nomadic. I quite believe from observation that wasps can and do run these insects down by scent, although it is difficult to obtain direct proof of the fact. They seem quite capable of discerning between their prey and enemies, as shown above; and granting this, it does not seem a great stretch to a further development of instinct having the propagation of the species in view.

Can any of your readers explain to me in what manner the spiders are stupefied and not killed?

I have lately noticed cases of protective mimicry in birds which I think are worth recording.

While following a small wood-swallow (*Artamus minor*) a few evenings back, they suddenly disappeared near a large leaning gum-tree. Walking up to the spot they suddenly flew out of the trunk, which I found had been hollowed out by fire, leaving the inside charred and black. The birds had chosen this black surface as their roost, and when followed in the day-time invariably flew into this refuge. It was impossible to detect the birds when clinging to the charred surface, with which their plumage matched.

Artamus albiventris, I find, in like manner chooses a greyish back as a roost against which they are less liable to be detected. *Erythrina vespertilio* is a favourite tree with this species.

I have on several occasions taken *Podargus giganteus* and other species alive by hand in broad daylight. These birds sit perfectly still on a limb of an iron-bark or acacia, whose bark resembles their plumage in colour. W. E. ARMIT

Georgetown, Queensland, July 19

Agricultural Ants

I HAVE lately discovered a colony of agricultural ants near Georgetown. The species is very small and red.

My attention was first directed to these tiny harvesters by noticing heaps of chaff and hulls in a bare spot situated in a grove of young acacia trees.

The formicaries are entirely subterranean, being entered by a funnel-shaped tube.

Roads diverge from this gate in four or five directions, and during working hours are alive with what appear like white insects, the little ants being covered by their load. Some of these ants seem to clean the grain and carry out the husks, which form a heap round the opening to the nest. The clear space round each opening is small, certainly not more than eighteen inches in circumference, and a small mound not more than six inches in height is formed with the earth excavated in forming the nest. The only species of grain harvested is the seed of *Perotis rara*, whch is light when quite ripe. I cannot give the generic name of these little fellows, never having devoted any special study to the family, but shall be happy to furnish specimens in spirits to any naturalist who will forward his address. WILLIAM E. ARMIT

Dunrobin, Georgetown, July 19

Meteor

AT about 5.50 P.M. to-day I saw a most brilliant meteor fall quite close to the moon, which was shining brightly at the time: it was in full daylight, shortly after the sun had gone down. Its direction was nearly perpendicular, but inclined a little from north to south as it fell. It was of a bright green colour; its motion rapid, its path long, and the time during which it was visible about two seconds, and it left no visible trace behind it.

Harlton, Cambridge, October 8 O. P. FISHER

JANSSEN'S NEW METHOD OF SOLAR PHOTOGRAPHY

IN two papers published respectively in the *Comptes Rendus* for December, 1877, and in the *Annuaire* of the *Bureau des Longitudes* for the current year, M. Janssen has described a new method of photographing the solar disc, which he has successfully carried out at the Meudon Observatory, during the past twelve months; and he has also drawn attention to some striking features in the constitution of the photosphere, disclosed for the first time in the beautiful pictures which are among the first results of his process. These may be regarded as only the forerunners of further important discoveries. Through the courteous liberality of M. Janssen, I have lately had the advantage of studying the process in the Meudon Observatory, and a description of its distinctive features, and a brief notice of such of the results as M. Janssen has already published, will certainly be acceptable to many who are interested in the recent developments of solar physics, and have not ready access to the original papers.[1]

M. Janssen's pictures of the solar disc are distinguished from all those previously obtained with the photoheliograph, not only by their great size (30·5 ctm. diameter), but more especially by the remarkable sharpness and definition with which they display the details of photospheric structure, which are such that, for the purpose of their more effective study, it is found advantageous to enlarge the original pictures to three and even nine times their original linear dimensions. The greatly extended means of research which M. Janssen's invention places in the hands of the solar physicist will be obvious, when we consider the difficulties which attend any prolonged ocular inspection of the solar disc, hitherto the only practicable method of examining its detailed structure. "In spite of the interposition of coloured glasses, helioscopes, &c., the eye must seize on the details in a dazzling field, and perform its functions under conditions which are quite unfamiliar. The true variations of luminous intensity in different parts of the image can no longer be appreciated, and the impressions produced do not correspond to reality. Thus may be explained the diversity of the opinions which have been put forward respecting the forms and dimensions of the granulations, and of the constituent parts of the solar surface"—diversities well illustrated by the old controversy of the "willow-leaf" and "rice-grain" bodies in the photosphere. In M. Janssen's pictures the forms, sizes, and arrangement of the bodies described under these appellations are exhibited in the most satisfactory manner, and as, in a favourable state of the atmosphere, the pictures may be repeated at as short intervals as the operator pleases, the movements and changes of form exhibited by these bodies may be studied with the utmost ease in a register which preserves the most fugitive phases of their appearance, and is available for leisurely re-examination at any future time.

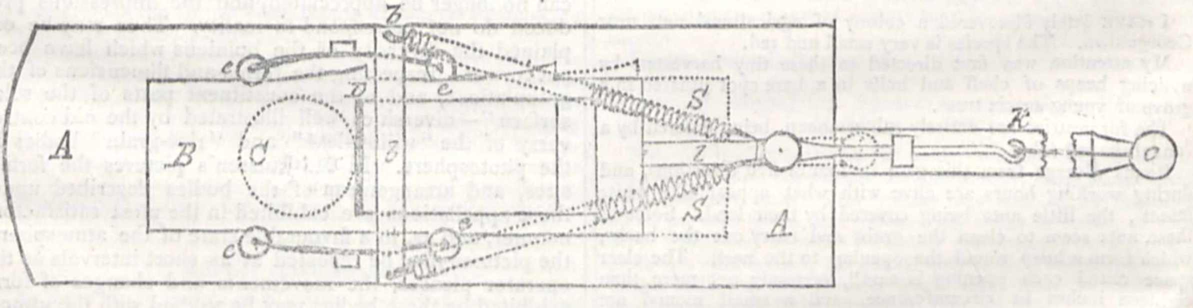
Before noticing the novel facts which M. Janssen has thus brought to light, I will briefly describe the principles of the process itself. The main difficulty to be surmounted in order to obtain a sharply defined photographic picture of the details of the solar disc is presented by the phenomenon known as photographic irradiation, in virtue of which a brilliantly illuminated surface occupies, on the negative picture, a proportionally exaggerated space; its borders being extended over the darker objects around. This phenomenon, M. Janssen remarks, "is very striking in all the photographs of total eclipses which have been obtained since 1860, which exhibit the images of the protuberances encroaching on the lunar disc, to the extent, in some cases, of ten and twenty seconds of arc, and even more." The granulations (to employ M. Janssen's terminology) visible on the solar disc have a mean diameter of not more than one second of arc, and in ordinary photoheliograms their very existence is therefore completely masked by irradiation.

[1] The present notice contains a more detailed description of the process than M. Janssen's original papers, and is published with his full approval and authority. With characteristic liberality M. Janssen writes:—"Quant au procédé lui-même, il est evident que toute personne un peu au courant de la photographie astronomique pourra l'appliquer et obtenir bientôt des photographies semblables à celles que nous obtenons. Je serai aussi très probablement devancé sur plusieurs points de la constitution du soleil que ces procédés peuvent révéler. L'inconvenient n'est que pour moi, et je crois qu'il vaut mieux dès aujourd'hui livrer la méthode au public scientifique. Les progrès de la science y gagneront certainement."

The simple and beautiful contrivance by which M. Janssen has succeeded in getting rid of irradiation, is to restrict the photographic action to one small sheaf of rays of the spectrum, viz., those which extend from the line G a short distance towards H. In a series of experimental photographs of the spectrum which M. Janssen took in my presence (with calc-spar prisms and a rock-crystal lens) and in which the time of exposure was varied successively from two-thirds of a second to three minutes, those obtained with the shortest exposure represented only that part of the spectrum immediately contiguous to G and extending a short distance towards H; and in this, the spectral lines were exhibited with extreme sharpness. With a more prolonged exposure the range of the image was greatly extended in both directions, accompanied by intensified action in the G–H region, which impaired the local definition.[1] Taking advantage of this fact, in the new process, the collodionised plate is exposed to the sun's action only so long as to allow of the action of the most actively photographic rays, and this is the cardinal condition of success. In practice, the duration of the exposure is restricted to between $\frac{1}{2000}$ and $\frac{1}{3000}$ of a second, in summer, being varied according to the season and to the time of day. The means by which this delicate adjustment is effected and verified will be described presently.

A second condition is, so to adjust the distance of the sensitised surface from the lens of the instrument, that it shall exactly coincide with the focus of the G rays. The necessity of this precaution will be readily understood when it is borne in mind that no lens is perfectly achromatic, and that, in virtue of the first condition, the rays in the vicinity of G alone produce the image. The remaining conditions are, the adoption of as large a plate as can be readily manipulated and some improvements in the process of preparing and developing the plates, whereby a very perfect surface is insured for the reception of the image, and a graduated development after exposure.[1]

The photoheliograph employed was constructed specially for the Meudon Observatory by M. Prazmouski of Paris. It has an object-glass of five inches diameter, and a reversing ocular, giving an erect image on the sensitized plate. The finding telescope casts an image on a disk of ground glass; by observing which, the operator can judge the exact instant for releasing the sliding screen, which causes the instantaneous exposure of the sensitised plate. At present, the position of the telescope is adjusted by means of winches worked by hand. The construction of the sliding screen, on the accurate adjustment and working of which the success of the operation mainly depends, will be understood on reference to the accompanying rough diagram (which, however, is not drawn to scale, and in which, to avoid confusion, some of the minor details are omitted). A A is an oblong brass plate which serves as a frame for the mechanism, and is introduced through a slit in the side of the telescope, exactly at the spot where the real image is formed by the object-glass. At the spot where the image falls, the plate is pierced with a circular aperture somewhat larger than



the image, shown by the dotted circle C. But this is completely covered by the sliding screen B, excepting such portion as is momentarily uncovered by the transverse slit D, in its passage across the image. The width of the sl t D can be varied by means of a micrometer screw, which is omitted in the diagram. The sliding screen works between four small grooved wheels *e e*, fixed to curved springs, which press them against the edges of the screen-plate; and one of these edges is shaped in the manner shown in the diagram, so that the pressure is increased from the instant at which the slit D reaches the margin of the circular aperture C, neutralising the acceleration of the movement by the continued action of the springs, and rendering it uniform during the passage of the slit across the image.[2] Thus the image is allowed to fall on the sensitised plate, not as a whole, but in successive slices, and the width of the slit is so adjusted to the rate of motion, that each slice is exposed during from $\frac{1}{2000}$ to $\frac{1}{3000}$ of a second only. The motion of the screen is effected by three spiral springs, two of which S S, are shown in the diagram (the central spring being omitted). The fixed ends are attached to a bar *b b* screwed to the slide A A; the free ends to a stud on the bar *l* which projects from the proximal end of B, is bent twice at right-angles and terminates in the hook *k*. In setting the screen before operating, a loop of twine is passed over the hook, which is then drawn towards the clip *c*, extending the springs S S, and bringing the screen into the position shown by a dotted line on the diagram. The twine is made fast in the clip *c* and all is in readiness for the operation. At the critical moment, the retaining string is cut and the slit D is rapidly drawn by the tension of the springs across the field, till checked by a stop not shown in the diagram. The movement of the screen is generally horizontal, but a gravity compensation is attached which can be employed when the movement is vertical.

The rate of the movement and the uniformity of the motion are determined by attaching, by means of wax to any part of the sliding screen, a glass slip coated with lamp-black. A tuning fork with an attached bristle, being made to vibrate transversely to the movement of the screen, the latter is released as in the actual operation of photographing, and the length of the wave marked by the bristle on the carbonised surface, multiplied by the width of the slit D, and divided by the number of vibrations of the fork per second, gives the duration of the exposure; while the uniformity of the movement is tested by the equality of the wave-lengths, which correspond to the passage of the slit D across the circular aperture C. By this means, the uniformity of exposure can be regulated to $\frac{1}{10000}$ of a second.

In order to obtain the exact position of the sun's axis on the plate, the instant of the exposure is noted by the

[1] Owing probably to spherical aberration.

[2] This, M. Janssen suggests, may be otherwise effected by an arrangement which will arrest the action of the springs at the instant when the slit reaches the margin of C.

[1] In this part of the process, M. Janssen acknowledges the assistance of M. Arents, to whom the writer is also indebted for much information.

chronometer, and the exact level of the slide containing the sensitized plate is observed with an accurate clinometer before removing it from the camera.

As M. Janssen has pointed out, the chemical preparation and development of the plate require very great care, in order to obtain the requisite sharpness of detail. The gun-cotton for the collodion is prepared at a high temperature (70° C.), and numerous precautions are taken to ensure that the collodion film shall be perfectly even, and free from the smallest speck of foreign matter. The image is developed gradually, beginning with a solution of ferrous sulphate, and after thorough washing, completing with a solution of pyrogallic acid, after which the image is strengthened with a mixture of pyrogallic and silver nitrate solutions.

In a favourable state of the atmosphere, the pictures thus obtained leave nothing to be desired in point of sharpness and definition of detail. But, as a matter of course, all states of the atmosphere do not permit of equal success, the process being subject to the same atmospheric contingencies as in all astronomical work with the telescope. The best results were obtained in the late autumn, and during this last spring.

The character of the photospheric surface as displayed in the new photographs, will be best described in a translation of M. Janssen's own words: "The photographs show that the solar surface is covered everywhere with a fine granulation. The forms, dimensions, and arrangement of the granular elements are very varied. Their size varies from some tenths of a second to three or four seconds. The shapes are circular or elliptical, and more or less elongated; but often these regular forms are more or less distorted. The granulation is exhibited everywhere; and, at first sight, it does not appear to present a different constitution towards the polar regions. But this is a point to be further investigated. The illuminating power of the granular elements, taken separately, varies much; they appear to be situated at different depths in the photospheric layer. The most luminous of them, those which more especially contribute to the luminosity of the photosphere, occupy but a small fraction of the surface of the sun.

"But the most remarkable result yet obtained, and which is exclusively due to the employment of the photographic method, is the discovery of the photospheric network (*réseau photosphérique*). An attentive examination of the photographs shows that the photosphere has not an uniform structure throughout, but is divided into a series of figures, more or less distant from one another, and exhibiting a special constitution. These figures generally have rounded contours, but also often rectilinear and sometimes polygonal. Their dimensions are very variable, and they sometimes attain to a minute or more in diameter. While, in the intervals between these figures, the grains are distinct and definitely bounded, although of very variable size; in their interior, the granules are half obliterated, drawn out and confused; most frequently, indeed, they have disappeared, giving place to trains of matter which replace the granulations. Everything indicates that, in these spaces, the photospheric substance is subject to violent movements which have confounded the granular elements. . . . This fact enlightens us as to the forms taken by solar activity, and shows that this activity is always very great in the photosphere, even though there be no spot visible on the surface. I will further draw attention to this very important fact, of which very distinct evidence is furnished by certain photographs, viz., that numerous very dark points appear in the regularly granulated tracts, indicating that the photospheric layer can have but a very small thickness."

In another paper, Mr. Janssen deduces some further conclusions of interest. He observes:—

"If the solar layer which forms the photosphere were in a state of repose and perfect equilibrium, it would result from the fact of its fluidity, that it would form a continuous envelope around the solar nucleus. The granular elements would be confounded together, and the lustre of the sun would be uniform in all its parts. But the ascending gaseous currents do not admit of this state of perfect equilibrium. They break up and divide the fluid layer, escaping at a great number of points. Hence results the formation of the granular elements, which are but so many fractions of the photospheric envelope, and which tend to take a spherical form, in virtue of the gravity of their constituent parts. . . . But even this state of equilibrium of the individual parts is but rarely realised; in numerous points, the currents drag along with them the granular elements, and these latter lose their spherical form, and eventually become no longer recognisable where the movements are most violent. . . . Moreover, in the regions of relative calm, the movements of the photospheric medium do not allow the granular elements to arrange themselves in an even layer, whence results the greater or less immersion of the grains beneath the surface, and consequently, owing to the great absorptive action of the medium, the great differences of their lustre shown in the photographic pictures. . . . We may further conclude, from the fact of the relative rarity of the most luminous grains in the photographs, that the illuminating power of the sun is due principally to that of a small number of points on his surface. In other words, if the solar surface were completely covered with granular elements of equal brilliancy with these, its illuminating power, according to a first approximate estimate, would be from ten to twenty times greater than it is." It will be interesting to ascertain, at the next epoch of sun-spot maximum, whether the brilliant granules occupy a relatively larger proportion of the solar disc than at the present time. The direct evidence which such an observation will afford on the important question of the periodic variation of solar radiative intensity, a question on which much diversity of opinion still exists, will be of the highest value.

H. F. BLANFORD

BIOLOGICAL NOTES

THE ANATOMY AND AFFINITIES OF THE AYE-AYE.—Dr. Alix having recently dissected a young male Aye-aye (*Chiromys Madagascariensis*), communicates, through Prof. Gervais, to the Academy of Sciences of Paris (*Comptes Rendus*, July 29, p. 219), some notes on certain points in its anatomy which bear upon the much-vexed question of the position of this curious animal in the mammalian series. It seems that his observations confirm in all points the opinion of all those eminent naturalists who, in accordance with De Blainville, and contrary to Gmelin and Cuvier, have held that the Aye-aye must be approximated to the lemurs and separated from the rodents, fresh facts being brought forward in support of this view. First, as regards its myology. The extensor communis hallucis, which in rodents is attached to the outer condyle of the femur, arises in the Aye-aye from the tibia. The biceps brachialis, which has only one head in the majority of rodents, has two in the Aye-aye. The supinator longus, which is generally absent in the rodents, has in the Aye-aye a good development. The common extensor of the digits, to those of the hand or foot, is composed of two distinct fascicles, of which one furnishes the tendons of the second and third digits, the other those of the fourth and fifth, from which it results that the Aye-aye, like the other Lemurina, possesses a paired digital system, and resembles in this feature the cloven-hoofed Pachyderms and the Ruminants, while the other mammals have, under all relations, an unpaired digital system. Dr. Alix has, moreover, verified the presence of a rotator muscle of the fibula, previously mentioned by Dr. Murie and Mr. Mivart in their paper upon the anatomy of the Aye-aye, published in the *Proceedings* of the Zoological Society. In examining the nervous system of the cervical region arrangements were discovered quite different from those seen in rodents. For example, the trunk of the great sympathetic nerve, which is otherwise separated from the pneumogastric in the whole extent of this region, has no middle cervical ganglion, but only an inferior one, excessively reduced in bulk. The superior cervical ganglion, situated immediately above the bifurcation of the common carotid, adheres by its fibrous sheath to the pneumogastric; and it is at this spot that the superior laryngeal nerve detaches itself from the pneumogastric, crossing the ganglion with which it enters into connection. On the left side there is no indication of a nervous filament answering to a depressor nerve, while on the right there may be seen to detach themselves from the superior laryngeal nerve two filaments of excessive tenuity which go to rejoin the trunk of the great sympathetic nerve. Nothing in this arrangement suggests resemblance to the nervous cord so distinct among the rodents, and above all among the Leporidæ, which, from this very circumstance, have furnished physiologists with the opportunity of making experiments of the greatest value. This character distinguishes the Aye-aye also from the opossums, which were placed by Illiger with the apes and lemurs in his order "Pollicata." The nervous arrangements, in short, confirm the results arrived at by the study of the muscles, viscera, and organs of generation, of the external form, skeleton, and dentition. J. C. G.

PROF. CARUEL'S CLASSIFICATION OF THE VEGETABLE KINGDOM.—At the close of his recent work, "La Morfologia Vegetale," Prof. Caruel of Pisa proposes a classification of the vegetable kingdom which has not so much of novelty in its principles of classification as in its terminology and the salient characters of the groups. He makes the following five primary groups, viz.:—1. PHANEROGAMIA. Every individual is trimorphic. The first form is neutral, and is capable of indefinite development, and of organic reproduction, principally by means of buds. This organic form gives rise, through the medium of the flower, to the two other (sexual) forms, male and female, which have only a definite development. The male form or pollen is thalloid; the female form or gemmule (ovule) is cormoid; this last produces, first, a pro-embryo as the result of the fecundation by the fovilla of the pollen, of an oosphere contained in a closed oogonium, and finally, the embryo of the neutral form, which develops at the extremity of the pro-embryo and in the same direction. In the subdivision of Phanerogamia, Caruel discards the distinction between Gymnospermia and Angiospermia, retaining, as the two primary classes, Monocotyledones and Dicotyledones, and giving the higher rank to the former. 2. SCHISTOGAMIA, including Characeæ only. These are also trimorphic; but the male sexual form consists of vermiform phytozoa (antherozoids) instead of pollen-grains, formed in an antherocyst (antheridium) differing in structure from the anther; the female form consists of an oogemma (archegonium) comparable to a gemmule, but naked; the neutral form springs directly from the oospore, which, on germinating, produces the embryo transversely. 3. PROTHALLOGAMIA, or Vascular Cryptogams. These are also trimorphic The neutral form does not produce the two sexual forms, but spores; these, on germinating, are transformed into sexual prothallia, with archegonia and naked oospheres, and vermiform phytozoa contained in antheridia; the oospore gives rise transversely to the embryo of the neutral form. The Prothallogamia are divided into Heterosporæ and Isosporæ. 4. BRYOGAMIA (synonymous with Muscineæ). The distinguishing character of this group is the indefinite power of development of the female individual, together with the definite development of the neutral form or sporogonium. A consequence of this is the continued and repeated fecundation of which the female form is capable, which distinguishes the Bryogamia from the three preceding groups. The embryo springs directly from the oospore; the male forms are phytozoa. The group is divided into Musci and Hepaticæ. 5. GYMNOGAMIA (Thallophyta or Cellular Cryptogams). The simplest Gymnogamia possess only a single form, which is reproduced agamically by fission, by conidia and sporidia, or by gamogenesis, but without any sexual differentiation. In others there is sexual differentiation into male and female forms; a few have also a third neutral form, when the oospore produces zoospores, instead of passing directly into the female form. They resemble the Bryogamia in the definite development of the neutral form and the indefinite development of the female form, but differ in the zoospore-like form of the phytozoa, and in the structure of the oogonium, which is isolated and naked, and does not form part of an archegonium. Prof. Caruel altogether discards the old classification of Thallophytes into Algæ, Fungi, and Lichens, but does not propose any other in its place, thinking it probable that, as our knowledge of some of its forms increases, it will be broken up into several primary groups He thinks it would be an advantage if the term Cryptogamia were altogether disused.

TRANSITION FORMS OF CRINOIDS IN AMERICAN PALÆOZOIC ROCKS.—Messrs. C. Wachsmuth and F. Springer have carefully studied the crinoids of the subcarboniferous rocks of the Mississippi valley, especially the Burlington and Keokuk limestones. There is probably no region in the world which exhibits, within the same limited geographical extent, so great and uninterrupted a range of crinoidal deposits in geological succession, almost unaltered. These observers conclude that extravagant forms and developments are not perpetuated, and that types mostly cease to exist when they reach a culmination in anatomical features. A large proportion of the genera become extinct in the formations above mentioned. The extinction of specific forms was not coincident with the close of the respective epochs of limestone deposits, but most of the changes were made by a series of slow and gradual modifications of specific characters, which correspond in a striking manner with the changes in individual life by growth. The smaller and less conspicuous forms were generally persistent, and ranged through the whole crinoidal formations with comparatively little change.

GEOGRAPHICAL NOTES

ACCORDING to present arrangements, we believe that Mr. Keith Johnston, the leader of the expedition which the Committee of the African Exploration Fund are about to despatch from the East Coast of Africa to Lake Nyassa, will leave England on November 14 for Zanzibar, together with his second in command, Mr. Thomson, whose more especial function it will be to study the geology of the country traversed. Mr. Thomson, we believe, has had an excellent training as a geologist, and it is expected that he will make important contributions to our knowledge of the geology of the region to be visited. The expedition will not actually start for the interior till next spring, and the interval will no doubt be utilised in making short journeys on the mainland, and in procuring all information possible in regard to the inhabitants, language, &c., of the region which is about to be thoroughly and scientifically explored. We sincerely trust that Mr. Johnston may not meet with the same trouble in the matter of porters as has so long retarded the progress of the Belgian and one or two other expeditions, but we do not hear that the Royal Geographical Society have formally given in their adhesion to the most recent suggestion for facilitating African travel by the purchase of one or more Indian elephants.

THE *Moniteur Belge*, of October 12, publishes late intelligence respecting the International Association's East African Expedition, gathered from communications dated Zanzibar, September 17. The seventy-one porters engaged by M. Greffulhe were at Bigviro on August 22, and 200 others had been collected through the exertions of Père Etienne, Superior of the Mission at Bagamoyo. It was expected that they would have joined M. Wautier at Mwoméro on September 18. The *personnel* of the expedition is, therefore, now complete, and the travellers will have started by this time to rejoin M. Cambier with the baggage abandoned by the deserters. We further learn that Dr. Dutrieux wrote from Mpwapwa on August 26 to M. Greffulhe, stating that M. Cambier was pursuing] his journey and was then at Kididimo, about 400 kilometres from the coast. His letter reached Zanzibar on September 4, and since then no fresh news has been received of the movements of the members of the expedition. There seems to be no truth in the rumour that the members of the Belgian expedition have been assassinated.

THE Dutch vessel *William Barends* has returned to Amsterdam from her voyage to the Arctic regions. It is stated that the voyage has been very successful from a scientific point of view, and it is expected that a full account of the discoveries made will shortly be published.

PETERMANN'S *Mittheilungen* contains an article on Turkey as it stands according to the Berlin Treaty, with a map. Dr. Emin Effendi's narrative of his journey in the African Lake Region is concluded, and an accompanying map shows the present position of the question as to the Muta Nzige, according to the data furnished by recent explorers. The south end of the Albert Nyanza lies to the north of 1° N. lat., and to the south is another Muta Nzige, of which Stanley's Beatrice Gulf is a southern extension. The Victoria Nile, between 1° and 2° N., and on the 33rd degree of E. long., broadens out into two lakelets, Gitansege and Codscha. Herr Kanitz contributes an interesting geological and physical paper on the Balkans. Perhaps the most interesting paper is one by Prof. H. Fritz on the periodical changes in the length of glaciers. The author has collected a large number of historical data to prove that there has been something like regularity in the changes of the Alpine glaciers. Important factors in seeking for the causes of change in the length of glaciers are temperature, snowfall, atmospheric moisture, clouds, direction of the wind, and atmospheric pressure. Prof. Fritz seems also of opinion that a connection may be traced between sun-spots and changes in the length of glaciers. The subject is of importance in various directions, and we trust that Prof. Fritz will continue the observations which he has so well begun.

RECENT advices, up to the beginning of September, have been received from Prof. Hayden, in the geyser regions of the Yellowstone, where the work of the survey was being prosecuted with great energy. Shoshone has been thoroughly mapped and explored, and the mammoth hot spring was next to be visited. Mr. Jackson has made large numbers of superb photographs of the geysers and other points of interest. Investigations into the temperature, composition, and other features of the hot springs are being carefully made, and a map is in progress on the scale of one inch to the mile. The survey of Point of Rocks, on the Union Pacific Railroad, along the west side of the Wind River Mountain, will next be attempted; thence he will proceed by Snake River on the east side of the Teton range to the sources of the Snake River. Dr. Hayden expected, after spending the month of September in the Park, to return along the east side of the Wind River Mountains *viâ* Camp Brown to Rawlins, on the Union Pacific Railroad, thence to Cheynene, which point it was hoped to reach on October 20.

WE have already noticed from time to time the movements of Mr. F. A. Ober, who has been engaged for two years under the auspices of the Smithsonian Institution in exploring the natural history of the West Indian Islands. His researches relate more particularly to the birds, his object being to secure the typical forms of all the islands, so that the West Indian fauna can be studied as a whole, his attention not being confined to one or two only of the islands. He has been extremely successful in his work, and has sent in numerous collections of much interest, embracing many new species, together with quite a series known previously by single specimens only. Last advices were dated Martinique, August 18. He expected to start for Guadeloupe on August 20, and to proceed thence to Marie Galant.

DR. E. TIETZE has just published in the *Jahrbuch* of the Vienna Geological Society an important paper on Mount Demavend, with a map of the mountains of the surrounding region. Demavend, according to the author, is a volcano in the solfatara condition, whose activity has waned within the memory of man. Its highest point, which even now gives out hot gases, contains a small crater, and stands inside the ruins of an older crater wall of larger diameter.

WE have received the first volume of Dr. Lenz's account of his explorations in West Africa. The second volume will appear in the beginning of next year, and Dr. Lenz hopes to publish during the present winter the geological results of his African travels, with a geological map of Guinea, and several plates of fossils.

WE have received from Mr. Stanford two new maps bearing on the present political difficulties in Asia: one is a map of "The Indian and Afghan Frontiers," the other, "A map of Western Asia." In the former the physical features are boldly drawn; here we may see how the present political boundary of India, having already passed beyond the broad and unbridged Indus, has yet stopped short of the next natural frontier, ending apparently at the foot of the mountains, but nowhere in particular. And what mountains! Commencing at the southern extremity of the map with the modest elevation of 5,390 feet, they stretch northwards at an ever-increasing altitude, until at the northern extremity we read 18,900 feet. The marking of many altitudes is a commendable feature in this map. The political colouring is somewhat startling; we did not expect to find that there is so broad an interval generally between the Indian and Afghan frontiers; they appear to be coterminous only at Thul in the Kuram Valley. The other map embraces, as its name implies, a much wider area, and shows by colour the latest extension of the Russian frontier in the direction of the mountains of Central Asia. As the British frontier has advanced to the foot-hills on the southern side of this great mountain mass, so the Russian frontier has advanced, or is rapidly advancing, to the northern foot-hills. This mass, with a breadth of about 200 miles, and an average elevation of more than 10,000 feet, with sundry passes of 12,000 and 13,000 feet, is all (!) that intervenes between the British and Russian frontiers. The new Indian frontier railways are correctly shown on these maps; with the exception of a break at Sakkur, on the Indus, and about 100 miles yet to make from Rawul Pindi to Peshawur, we have railway communication all along the landward frontiers of India, from Kurrachee to Calcutta.

NEWS from Munich states that Dr. Eugene Forel is about to start on a scientific exploring tour to New Granada.

ON THE NATURE OF VIBRATORY MOTIONS[1]

III.

Experiments by which Compound Sounds are analysed by viewing in a Rotating Mirror the Vibrations of König's Manometric Flames.

TAKE a piece of pine board, A, Fig. 15, 1 inch (25 millimetres) thick, $1\frac{1}{2}$ inch (38 millimetres) wide, and 9 inches (22·8 centimetres) long. One inch from its top bore with an inch centre-bit a shallow hole $\frac{1}{8}$ inch deep. Bore a like shallow hole in the block B, which is $\frac{3}{4}$ inch thick, $1\frac{1}{2}$ inch wide, and 2 inches (51 millimetres) long. Place a $\frac{1}{2}$-inch centre-bit in the centre of the shallow hole in A and bore with it a hole through the wood. Into this fit a glass or metal-tube, as shown at E. Bore a $\frac{3}{16}$-inch (5 millimetres) hole obliquely into the shallow hole in B, and into this fit the glass tube C. Then bore another $\frac{3}{16}$-inch hole directly

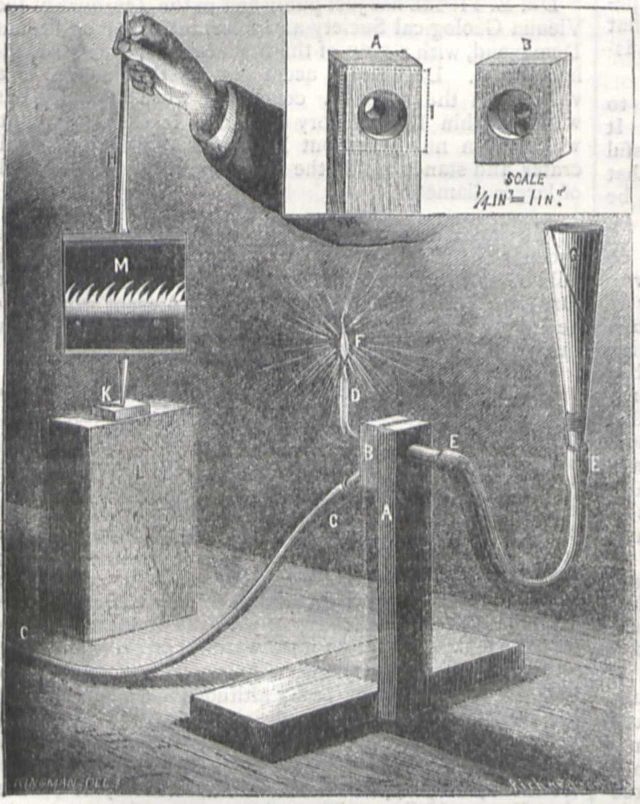


FIG. 15.

into the shallow hole in B. Put a glass tube in a gas or spirit flame and heat it red-hot at a place about two inches from its end. Then draw the tube out at this place into a narrow neck. Make a cut with the edge of a file across this narrow neck, and the tube will readily snap asunder at this mark. Then heat a place on the tube in a flame, and here bend it into a right angle, as shown at D, Fig. 15. Now fit this tube into the hole just made, as shown at D. These tubes may be firmly and tightly fitted by wrapping their ends with paper coated with glue before they are forced into their holes.

Get a small piece of the thinnest sheet rubber you can find, or a piece of thin linen paper, and, having rubbed glue on the board A around the shallow hole, stretch the thin rubber, or paper, over this hole and glue it there. Then rub glue on the block B, and place the shallow hole in this block directly over the shallow hole in A, and fasten B to A by wrapping twine around these blocks. Thus you will have made a little box divided into two compartments by a partition of thin rubber. Fasten the rod A to the side of a small board, so that it may stand upright.

Attach a piece of large-sized rubber tube to the glass tube E, and into the other end of the tube stick a cone, made by rolling up a piece of cardboard so as to form a cone 8 inches long and with a mouth 2 inches (51 millimetres) in diameter.

Now get a piece of wood 1 foot long, 4 inches wide, and $\frac{1}{4}$ inch thick. Out of this cut the square, with the two rods projecting from it, as shown at M. The lower of these rods is short, the one above the square is long. Cut the end of the shorter rod to a blunt point, and with this point make a very shallow pit in the piece of flat wood K for the rod and square to twirl in. Glue the piece of wood K on the end of a brick, L. Get two pieces of thin silvered glass, each 4 inches square, and, placing one on each side of the square M, fasten them there by winding twine around the top and bottom borders of the mirrors.

Experiment 16.—Through a rubber tube lead gas to C. It will go into the left-hand partition of the box and will come out at F, where you will light it. Now place the mirror-rod in the shallow pit in K, and hold the mirror upright so that you may see the flame F reflected from its centre.

Hold the rod upright and twirl it slowly between the thumb and forefinger, which should point downward and not horizontally, as shown in the figure. The flame appears in the mirror drawn out into a band of light with a smooth top-border. While twirling the mirror put the cone to your mouth and sing into it. The sonorous vibrations enter the side A of the box, and, striking on the thin rubber, force this in and out. When it goes in a puff of gas is driven out of the other partition, B, of the box, and the flame F jumps up. When the sheet of rubber vibrates outward it sucks the gas into the box B, and the flame F jumps down. Therefore, on singing into the funnel, you will see in the mirror the smooth top-border of the luminous band broken up into little tongues or teeth of flame, each tooth standing for one vibration of the voice on the rubber partition.

Place a lamp-chimney around the flame, should the wind from the twirling mirror agitate it, and be careful not to have the flame too high.

Experiment 17.—Another way of showing the vibrations of the flame is to burn the jet of gas at the end of a glass tube stuck into the end of a rubber tube attached to F. Now sling the tube round in a vertical circle, and you have an unbroken luminous ring; but as soon as you sing into the cone this ring breaks up into a circle of beads of light, or sometimes changes into a wreath of beautiful little luminous flowers, like forget-me-nots. To make this experiment you will be obliged to have a tube with a larger opening than that at F.

This instrument will afford you many an hour of instruction and amusement. We have only space to show you a few experiments. Others will suggest themselves whenever you use it.

Experiment 18.—Sing into the funnel the sound of *oo* as in p*oo*l. After a few trials you will get a pure simple sound, and the flame will appear as in Fig. 16. Some voices get this figure more readily by singing E.

Experiment 19.—Twirling the mirror with the same velocity, gradually lower the pitch of the *oo* sound till your voice falls to its lower octave, when the flame will

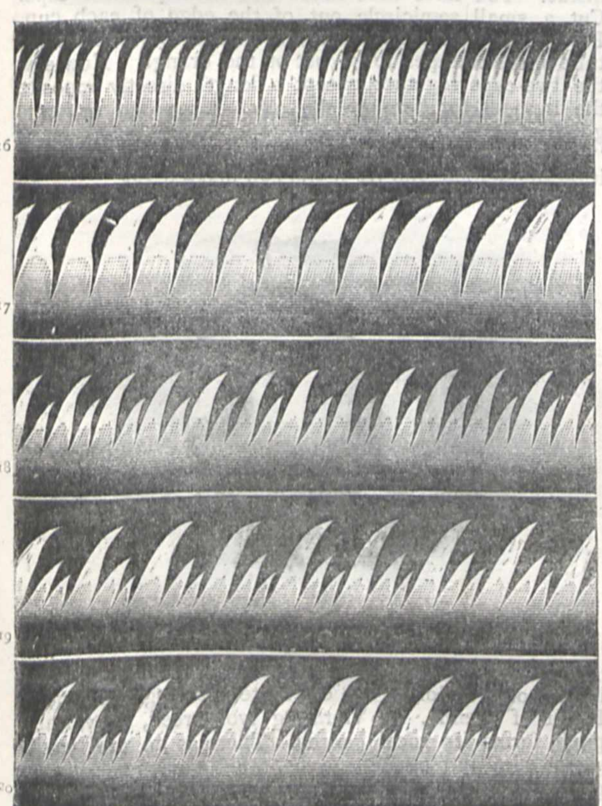
[1] From a forthcoming work on "Sound: a Series of Simple, Entertaining, and Inexpensive Experiments in the Phenomena of Sound, for the Use of Students of every Age." By Alfred Marshall Mayer, Professor of Physics in the Stevens Institute of Technology. Communicated by the author. (Continued from p. 556.)

appear as in Fig. 17, with half the number of teeth in Fig. 16, because the lower octave of a sound is given by half the number of vibrations.

Experiment 20.—Sing the vowel-sound *o* on the note

and you will see Fig. 18 in the mirror. This evidently is not the figure that would have been made by a *simple* vibration. It shows that this *o* sound is compound, and formed of two simple sounds, one the octave of the other. The larger teeth are made by every alternate vibration of the higher simple sound acting with a vibration of the lower, and thus making the flame jump higher by their combined action on the membrane.

Experiment 21.—Fig. 19 appears on the mirror when we sing the English vowel *a* on the note f.



FIGS. 16, 17, 18, 19, 20.

Experiment 22.—Fig. 19 appears on the mirror when we sing the English vowel *a* on the note c.

Examine attentively Fig. 19. This shows that the English vowel *a* sung on f is made up of two combined simple vibrations. One of these alone would make the long tongues of flame, but with this simple vibration exists another of three times its frequency; that is, the vibration of greater frequency is the 3rd harmonic of the slower. As the slower vibration, making the long tongues of flame, is f, the higher must be *c″* of the second octave above f. Each third vibration of this higher harmonic coincides with each vibration of f; hence each third tongue of flame is higher than the others.

Experiment 23.—In like manner the student must analyse Fig. 20 into its simple sonorous elements. Then he should, with the vibrating flame, examine the peculiarities of the various voices of his friends, and make neat and accurate drawings of the flames corresponding to them, so that he may analyse them at his leisure.

Experiment 24.—Blow your toy trumpet into the paper cone gently, and then strongly, and observe that the sound given by the trumpet is a complex one. Try if you cannot get a flame somewhat like the trumpet gives by singing *ah*, through your nose, into the cone.

The student will soon find that different persons, in singing the same note, as nearly alike as they can, will produce flames of very different forms. This is because the voices differ in the number and relative intensities of the simple sounds which form them.

Another cause of the different forms of flame obtained by different experimenters is due to the fact that they have used different lengths of tube leading from the cone to the membrane.

Experiment 25.—The fact can be readily shown by singing the same compound sound through different lengths of tube leading from the cone G to the membrane.

Terquem's Experiment, in which König's Flame is used instead of the Ear, and thus the Motions of a Vibrating Disk are made Visible.

The method of analysing the motions of a vibrating plate with the paper cone and tube applied to the ear, which has been used by us for a long time, has quite recently been adapted to M. König's flame by Prof. Terquem, of Lille, who has thus made these motions visible to the student, and has given us a charming experiment.

On how we Speak, and on the Talking Machines of Faber and Edison.—How we Speak.

The little musical instrument with which we sing and speak is formed of two flexible membranes stretched side by side across a short tubular box placed on the top of the windpipe. This box is made of plates of cartilage,

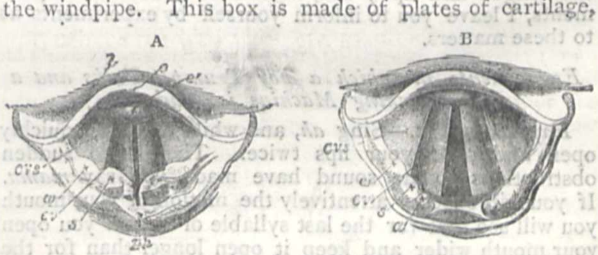


FIG. 21.

FIGS. A and B.—Views of the human larynx from above as actually seen by the aid of the instrument called the laryngoscope. Fig. A.—In the condition when voice is being produced. Fig. B.—At rest, when no voice is produced. *e*, epiglottis (foreshortened); *cv*, the vocal chords; *cvs*, the so-called false vocal chords, folds of mucous membrane lying above the real vocal chords; *a*, elevation caused by the arytenoid cartilages; *s*, *w*, elevations caused by small cartilages connected with the arytenoids; *l*, root of the tongue.

movable on each other, and bound together with muscles and membranes.

The top of the windpipe is formed of a large ring of cartilage, called the *cricoid* (ring-shaped) cartilage. Jointed to this is a broad plate of gristle, called the *thyroid* (shield-shaped) cartilage. This cartilage is bent into the shape of a V. The legs of this V straddle over the cricoid and are jointed to its outer sides. The peak of the V stands up and points toward the front of your throat. You can feel it, as it is the "Adam's apple." On the back of the upper edge of the cricoid ring are jointed two small pointed cartilages, known as the *arytenoid* (funnel-shaped) cartilages. Stretching from these to the inner sides of the legs of the V of the thyroid are two membranes, one to each leg. These are the *vocal chords*.

When the point of the thyroid is not pulled down these membranes are lax, and the breath from the windpipe passes freely between them and does not make them vibrate. (*See* B of Fig. 21.)

But when the peak of the thyroid is pulled down by its muscles the vocal chords are stretched. At the same time the arytenoid cartilages move nearer each other, and the thin, sharply-cut edges of the vocal chords are brought parallel and quite close to each other, as is shown in A of Fig. 21. If the air is now forced through this narrow slit (called the *glottis*), the vocal chords vibrate just like the tongue in our toy trumpet, or like the reed in any reed-pipe. A puff of air passes between them; they separate; immediately afterward they come close together and the current of air is stopped. They again open, another puff goes into the cavity of the mouth, and then they close together again. Thus the glottis opens and closes with a frequency depending on the degree of stretch on the vocal chords.

Our experiments with König's flame have shown how composite are the sounds of the human voice. The quality of a voice depends on the number and relative intensities of the simple sounds which build it up.

SPEECH is voice modified and modulated by the movements of the parts of the cavity of the mouth, of the tongue, and lips.

The oral cavity is made larger or smaller, longer or shorter, and thus, resounding to some lower or higher harmonic of the voice, makes the others feebly heard.

Experiment 26.—If you form your speaking organs to say *o*, and then take your vibrating A-fork and hold it before your lips, you will hear the cavity of the mouth resounding to this sound. On changing the vocal organs to say *e* the resonance ceases.

All the vowel sounds are formed by a steady voice modified by the resonance of the different sizes and shapes given to the oral cavity.

The consonants are made by obstructions placed at the beginning or end of the oral sounds, by the movements of the tongue and lips; but, as this is a book of experiments, I leave you to inform yourself by experiments as to these matters.

Experiments in which a Toy Trumpet Talks and a Speaking Machine is Made.

Experiment 27.—Sing *ah*, and while doing so quickly open and shut your lips twice. These two sudden obstructions to the sound have made you say *mama*. If you will observe attentively the motion of your mouth you will see that for the last syllable of mama you open your mouth wider and keep it open longer than for the first syllable.

Experiment 28.—This is all we have to know to make our toy trumpet talk. You already have seen that its sounds,

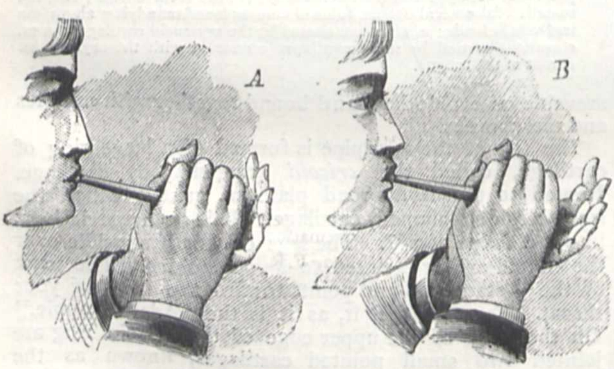


FIG. 22.

like those of the human voice, are made by puffs of air. These pass the reed every time it goes above or below the oblong hole in the plate in which it vibrates. Your experiments with König's flame have told you that the sounds of the voice are similar—that both are highly composite.

Let, then, the vibrating reed in the trumpet stand for your *vocal chords*. To get a resonant cavity like the *mouth* make one between your two hands, as shown in A of Fig. 22. The funnel of the trumpet is placed inside this cavity with the tube coming out in the crotch between the thumb and forefinger. The lips we will form of the fingers of one hand. By raising these together, more or less, from the other hand we can make a larger or smaller opening into the cavity between the palms of the hands, and thus get articulation.

Now blow into the trumpet as though you were speaking *mama* into it, so that you may make it sound twice, each sound lasting just as long as the sounds in mă and mā. While making the first sound, raise the fingers as high as is shown in A; while making the second, raise them as high as is shown in B. The trumpet talks and says *mama* quite plainly.

Experiment 28.—Let us make a talking machine. Get an orange with a thick skin and cut it in halves. With a sharp dinner-knife cut and scrape out its soft inside. You have thus made two hemispherical cups. Cut a small semicircle out of the edge of each cup. Place these over each other, and you have a hole for the tube of the trumpet to go out of the orange. Now sew the two cups together, except a length directly opposite the trumpet, for here are the *lips*. A pea-nut makes a good enough nose for a baby, and black beans make "perfectly lovely" eyes. Take the baby's cap and place it on the orange, and try if you can make it say

FIG. 23.

Faber's Talking Machine.

These simple experiments show the principles followed in the construction of the celebrated talking machine of Faber of Vienna. A vibrating ivory reed, of variable pitch, forms its vocal chords. There is an oral cavity whose size and shape can be rapidly changed by depressing the keys on a key-board. Rubber, tongue, and lips make the consonants. A little windmill turning in its throat rolls the *r*, and a tube is attached to its nose when it speaks French. This is the anatomy of this really wonderful piece of mechanism.

ELECTRIC LIGHTING

ALL the papers are still much occupied with correspondence about the electric light, the extent to which it may be brought into public use, and its possible effect upon the use of gas and upon gas companies. Many writers display much ignorance both as to the scientific and economical bearings of the matter; the most important communication on the subject that has appeared is the letter from Dr. C. W. Siemens in the *Times* of the 12th inst. Dr. Siemens writes as follows :—

The intelligence flashed through the Atlantic cable a few days since to the effect that Mr. Edison, the ingenious inventor of the phonograph, &c., had succeeded in dividing electric currents indefinitely, for the distribution of light and power appears to have taken the public by surprise, and has exercised a most depressing influence upon the holders of gas shares. Having given close attention to the question of electric lighting ever since 1867—when, following the researches of my brother, Dr. Werner Siemens, I presented a paper to the Royal Society describing the dynamo-electric principle—I may be allowed perhaps to make a few remarks upon the novelty and probable effect of Mr. Edison's startling announcement.

In passing an electric circuit from a main conductor into several or any number of branches, the current divides itself between those branches, according to the well-known law of Ohm, in the exact inverse ratio of the electrical resistance presented by each branch. A current may thus be divided, for instance, into ten separate currents of precisely equal force, if each branch is made to consist of a wire of the same length and conductivity; but if one of these wires was again to be slit into ten wires, presenting in the aggregate the same conductivity, each of these wires would only convey 100th part of the total current. In the same way one of the minor wires might again be subdivided into branches, each of which would convey an amount of electric current which would be accurately expressed by the relative resistance of the branch in question, divided by the total resistance of all the branches put together. It would thus seem that nothing could be more easy than to divide a powerful electric current among as many branches of varying relative importance as might be desired; but in the case of electric lighting a difficulty arises in consequence of the varying resistance of each electric light or candle, due to the necessarily somewhat varying distance of the carbon points from each other, upon which the length of the luminous arc depends. In order to work a number of lights upon different branches of the same current, it is necessary to furnish each branch with a regulator so contrived that an increase of current corresponding to too near an approach of the carbon points will produce automatically an increased resistance in that branch circuit, whereas an accidental increase in the distance between the carbon points of any lamp will cause the regulator to reduce the extraneous resistance of the circuit to a *minimum*. Such a mode of regulating currents was present in my mind when, in addressing the Iron and Steel Institute in March, 1877, I ventured to express my conviction that natural forces, such as represented by large waterfalls, could be utilised for the production of motive power and electric light, in towns at a distance even of thirty miles from such source, by means of a large electric conductor. This suggestion gave rise to a good deal of discussion and criticism, especially in the United States; but I replied to some of these criticisms in delivering one of the Science Lectures at Glasgow in March last, having already referred to the matter in a discussion that was held before the Institution of Civil Engineers on January 29 last. Having in the meantime perfected the regulator, I showed it in operation at the *soirée* of the Royal Society on June 19, and have only been waiting to get experimental data complete in order to bring the whole subject before one of the scientific bodies. The arrangement may be said to consist simply of a thin strip of copper or silver, say six inches long and half an inch broad, stretched horizontally between two supports with a weight or spring exerting a certain pressure in the middle. The branch current to be regulated is passed through this strip of metal, which is thereby heated to a certain moderate extent, depending upon the amount of current passing, and upon the rate of radiation of the heat produced in the strip to surrounding objects. Suppose that when the normal condition of things obtains, the strip of metal is maintained at the temperature of, say, 100° Fahrenheit, and suppose that by an accidental approach of the carbons of a lamp the resistance of the circuit is suddenly decreased, an almost instantaneous increase of temperature of the thin strip will ensue, which will cause it to elongate slightly, and allow the weight resting in the middle to descend, which in its turn causes an increase in the resistance of a small rheostat, through which the branch current in question has to flow.

It will thus be seen that it is not so much the novelty of the announcement made by Mr. Edison as the manner in which it has been conveyed to us that has alarmed a portion of the British public, and I hold that such startling announcements as these should be deprecated, as being unworthy of science and mischievous to its true progress.

Although I am strongly of opinion that electricity will gradually replace gas in many of its most important applications as being both cheaper and more brilliant, I still hold the opinion, quoted by Mr. Northover in his letter to you of yesterday, that its application will be limited, at least during our generation, to such larger purposes as the lighting of our coasts, to naval and military signalling, to harbours, quays, warehouses, and public buildings, including perhaps picture galleries and drawing-rooms, where the objections to gas are already felt to the extent of banishing that means of lighting to the passages, offices, and bed-rooms. I am, however, of opinion that a revolution even to the extent indicated must be the work of time, and that while gas will undoubtedly in due course be supplanted by its more brilliant rival for the purposes just indicated, the consumption of gas will be maintained by the increasing area of application resulting from increase of towns, and by additional applications for cooking and for heating purposes, for which gas will supplant the use of solid fuel, and thus confer a new benefit upon mankind by doing away with the nuisance of smoke and ashes. If gas companies only rightly understood their interests they would themselves take up electric lighting for those purposes for which it has the decided preference, and at the same time promote the application of gas for heating, in doing which they would clearly increase their business as lighting companies, while benefiting the public by providing them with the very best sources of heat and light.

NOTES

AT the request of the Chemical Society Prof. Ad. Wurtz, of Paris, has accepted the office of Faraday lecturer for this year. The subject of his lecture is "La Constitution de la Matière à l'État gazeux." The lecture is to be delivered on Tuesday, November 12, in the Theatre of the Royal Institution, Albemarle Street. On the following day the Fellows of the Chemical Society propose entertaining Prof. Wurtz at a dinner to be held at Willis's Rooms.

THOSE interested in the progress of natural science at our old universities should take notice of the fact that, after considerable opposition of the "Board of Studies of the Natural Science School," the majority of that Board (chiefly by the aid of the examiners, who are London, and not Oxford, men) have carried a series of resolutions which provide that "candidates for honours in biology" may be examined in experimental physiology. The necessary encouragement to the study of this subject, viz., examination in it as an "honour subject" now existing, we may hope to see as the result some activity in the physiological laboratory of Magdalen College. Similarly we have to notice the recognition of the morphology and physiology of the vegetable kingdom as a necessary part of the study and examination of the Oxford student who is a candidate for "honours in biology." Botany was long resisted and sneered at in Oxford. External pressure has, however, reinstated botany in the Oxford school of natural science, and it rests with the examiners in future to maintain the study of this subject in the direction indicated by Sachs' admirable treatise on Botany published by the University press.

THE following changes are proposed to be made in the Council of the London Mathematical Society for the ensuing session:—Mr. C. W. Merrifield, F.R.S., to be president in the room of Lord Rayleigh, F.R.S., who is proposed for the office of vice-president in conjunction with Prof. Cayley, F.R.S.; Messrs. J. Hopkinson, F.R.S., and H. M. Taylor to be ordinary members of council in the room of Prof. Clerk Maxwell, F.R.S., and Mr. T. Cotterell. The valedictory presidential address will probably be delivered at the annual meeting (November 14).

THE new specimen of *Archæopteryx lithographicus* of Solenhofen, the discovery of which was announced some time back, has been purchased by Dr. Otto Folger, President of the Freie Deutsche Hochstift, for the sum of 35,000 marks (1,750*l*.), and will no doubt be placed in the hands of some competent German palæontologist for description. It is said to be in several respects more perfect than the first, and hitherto unique, specimen in the British Museum, which has been the subject of the labours of Prof. Owen and Prof. Huxley on this most remarkable of extinct birds.

THE death is announced of M. Leymarie, Professor of Geology at Toulouse, and the author of the first geological map of France.

THE death, at the age of seventy, of Prof. William Monroe Davis, is announced as having taken place at Cleveland, Ohio, U.S., on July 21 last. When quite advanced in life Prof. Davis took up the study of astronomy, and has long been known as an original thinker and labourer in this field. After the resignation by Prof. Mitchell, as director of the Cincinnati Observatory, he was succeeded by Prof. Davis, who remained in charge for some considerable time. Of late years he has not been actively employed in any work, with the exception of the construction of a telescope, which has done excellent service in his hands.

THE Society of Arts announce that their opening meeting will be held on November 20, when the chairman's inaugural address will be delivered and the following medals presented:—The Albert Medal (gold), for "Distinguished Merit in Promoting Arts, Manufactures, or Commerce," to Sir William G. Armstrong, C.B., F.R.S., D.C.L. The council also announce that the following papers will be read:—On November 27, "The Land of Midian," by Capt. Burton; December 4, "The Electric Light," fully illustrated with experiments, by T. N. Shoolbred; December 11, "The Route to India, with especial Reference to the Euphrates Valley Railway," by Hyde Clarke; December 18, "Science Teaching in Elementary Schools," by Dr. Gladstone, F.R.S.; and the first course (six in number) of lectures by W. M. Williams on "The Manufacture of Mathematical Instruments."

A CORRESPONDENT makes the interesting suggestion that the microphone might be used to detect if insects have any audible means of communicating with each other, and if so, what is its nature in different classes of insects.

THE fourth annual conference of the Cryptogamic Society of Scotland was held in the Royal Botanic Garden, Edinburgh, on the 9th, 10th, and 11th inst., under the presidency of Prof. Balfour, and was a success in every way. The business meeting was held in the lecture-hall, and in addition to the president's address a number of papers were read relating to recent discoveries—both in species and in morphology—in cryptogamic botany. An excursion was made to the Penicuick woods, where about 170 species of fungi, including one or two new and several rare species, were noted. The public show was held in the winter garden and herbarium of the Royal Botanic Garden, and was visited by a great many people, who appeared to be much interested in the exhibition. A considerable number of hymenomycetes, &c., were arranged in classified order and named. Many distinguished botanists, both English and Scottish, attended the meeting, and were very hospitably entertained by the president and other members of the local committee. A notice of the scientific results of the conference will be given in the *Scottish Naturalist*. Next year's conference is to take place at Forres. Arrangements may be learnt from the secretary of the Society, Dr. Buchanan White, Perth.

MR. T. MUIR, M.A., of the High School, Glasgow, has forwarded to the London Mathematical Society a verification of Pervouchine's first result regarding the divisibility of $2^{2^{12}} + 1$ by $7 \cdot 2^{14} + 1$ (NATURE, vol. xviii. p. 104). The mode of verification will be understood from the following question and solution:—Is $11 \cdot 2^4 + 1$ a factor of any number of the form $2^m + 1$? $11 \cdot 2^4 + 1 = 2^7 + 2^5 + 2^4 + 1 = 10110001$ (radix 2). The question thus is—"Is there any number which when multiplied by 10110001 will produce a number of the form 1000...0001? Now knowing that the last digit of the multiplier and product is 1, we infer that the last digit of the multiplicand must be 1. Taking it as such and performing the multiplication we have—

```
.......1
10110001
--------
       ....1
   ....1000
     ....1
    ....0
   ....1
```

whence, in order that the result of the addition may be of the form ....0001, we see that the second, third, fourth, and fifth digits of the multiplicand must be 0, 0, 0, 1 respectively. Prefixing these to the first digit and continuing the multiplication we have—

```
      ....10001
       10110001
      ---------
      ....10001
  ....10001
 ....10001
..10001
---------------
```

from which on addition we deduce other four digits of the multiplicand; and so on. When we have got in all twenty-two digits the figuring is as follows:—

```
       10111001001000010100001
                      10110001
       -----------------------
       10111001001000010100001
   10111001001000010100001
  10111001001000010100001
10111001001000010100001
------------------------------
```

and we find that addition then gives a product of the required form; and thus we have the result—

$$2^{29} + 1 \text{ is divisible by } 11 \cdot 2^4 + 1.$$

When there are few significant figures in the multiplier, as here, it will readily be seen that a very considerable lessening of labour is possible, that, in fact, the digits of the multiplicand can be written down at a steady pace without any auxiliary figuring at all. This is what was actually done in Mr. Muir's verification of Pervouchine's first case. With reference to the editorial query as to how the trial divisors came to be thought of Mr. Muir refers to the *Turin Transactions* for the present year, where there is a paper by M. E. Lucas, which almost entitles him to the merit of being a sharer in the discovery.

THE excavations made in Carniola under the direction of Herr von Hochstätter, on spots of palæontological and prehistoric interest, have hitherto been crowned with every success. The Kreuzberg Cave, near Laas, in the district of Zirknitz, proved to be an exceedingly interesting bear cave. The investigations made in this district, at St. Michael, near Adelsberg, and at Klenke, near Waatsch, have furnished undeniable proofs of the existence of prehistoric colonies and burial grounds at these places. Another interesting discovery has just been made at the Laibacher Moor, the well-known pile-dwelling ground. A peat digger found six silver coins of the size of a florin, which all bear the inscription of the Roman Emperor, Augustus Claudius. The discovery has been secured for scientific purposes.

THE Paris Academy of Arts has recently acquired an Egyptian papyrus which is particularly remarkable on account of its reputed age, which is estimated at over 4,000 years. It is perfectly preserved; its height is 8·30 metres, and its width 43 centimetres.

It contains a description of the death and the burial celebration of the mother of King Herod, from the first dynasty of Egyptian kings. The price paid by the Academy was 4,000 francs (160*l.*); the papyrus is now in the Exhibition.

IN the August number of the *Moniteur Scientifique* M. J. Laurent, of Marseilles, cautions the scientific world generally, and chemists in particular, against the use of de la Bastie's toughened glass. He considers the objects and utensils made of this substance to be no better than so many Prince Rupert's drops or Bologna flasks, from which they differ only by their shape. M. Laurent adduces an instance where a dish made of toughened glass was used at a stearine factory at Marseilles; it suddenly broke into thousands of fragments upon being placed on the metal scale of a balance. It was then in a state of cooling down from 110° C., at which temperature it had been maintained for some time; but it had previously been in use for about a month, and its sudden destruction was entirely inexplicable, save by the theory above mentioned.

WITH reference to Vesuvius the *Libertà* publishes the following letter from Prof. Palmieri, dated October 6:—"The phase of minor activity of the crater continues, nor is there sign of any speedy increase. Little smoke, very little lava, and a certain lesser activity in the eruptions of the new cone represent the phases of decreasing dynamism. According to some, I have announced augmenting force with the growth of the moon. I must state that I only said that if there was to be any increase, it would be verified towards the time of the full moon, according to the laws I have noted since Vesuvius has been my study, and confirmed by irrefutable documents from which I have drawn the history of our volcano. But, however it may be, this eruptive period, long foreseen, appears to require time to reach the evolution of the major phases it will ultimately attain." Telegrams from Naples on the 13th announced greatly increased activity in the volcanic action of Vesuvius.

MESSRS. MACMILLAN AND CO. have in preparation a text-book, systematic and practical, on the "Physiological Chemistry of Animal Bodies, and on the Changes which their Tissues and Fluids undergo in Disease," by Prof. Arthur Gamgee, M.D., F.R.S. The author seeks to fill up an important gap at present existing in English medical and scientific literature by preparing a succinct, though complete, account of the chemical processes of the organism, and of the methods of studying them. The work will primarily be a didactic and systematic treatise, and, though in no respect a servile imitation, will be constructedon the same plan as Prof. Kühne's most admirable, though now necessarily almost obsolete, "Lehrbuch der physiologischen Chemie:" Leipzig, 1866. It will differ, however, even in plan from that book, in containing elaborate descriptions of methods of research and directions for the performance of analyses, which will in part be introduced into the systematic portion of the text, and in part be added as appendices to each section. These appendices will be so detailed and complete as to render superfluous a separate laboratory treatise on Chemico-Physiological Analysis, such as the excellent books of Hoppe-Seyler, and Gorup-Besancy. It is the object of the author to prepare a work which will not only be useful to specialists in physiology, but to physicians, by whose researches the most important facts in the chemical history of the body have been discovered in the past, as they doubtless will be in the future.

FOUR shocks of earthquake were felt at Mineo, in Sicily, early on the morning of the 5th.

THE severe thunderstorms of October 7, 8, 9, 10, which raged in several parts of France with an almost unprecedented fury, were preceded by strong siroccos in Algeria, where the heat had been quite oppressive. The thunderstorms advanced in France from the south northwards, and even in the British Channel strong south gales were felt. The perturbation lasted during five days, when the magnificent weather which had marked the beginning of October returned.

THE large balloon, the *Crusader*, which escaped from the Royal Arsenal, Woolwich, on Monday afternoon last, descended in the Port Meadow, near Oxford, at 7 o'clock the same evening.

AN interesting account of the annual fungus foray of the Woolhope Club will be found in the *Gardeners' Chronicle* of October 12.

THE *Courrier de Bone* says that a singular phenemenon was observed at Clousel, in the vicinity of Hammam Mex Kontine, one of the most celebrated thermal bathing-places in Algiers. After an earthquake which took place in the beginning of September, an immense rock was precipitated from the mountain. Some inhabitants visiting the place found the opening of a grotto at the bottom of which a lake was discovered. The water is quite fresh and almost at zero Centigrade.

ACTIVE preparations are being made for the meeting of the Social Science Congress at Cheltenham on the 23rd instant.

CAPTAIN PATTERSON, Superintendent of the U.S. Coast Survey, has lately initiated a very important undertaking in connection with the work of the Survey, namely, in determining the extent and position of the oyster beds of the Chesapeake Bay, primarily with reference to the formation of oyster reefs, and their interference with navigation, but broad enough in its scope to serve as the basis of a critical investigation of the whole subject of the oyster fisheries and oyster culture in the United States. It is somewhat curious that the best article upon the statistics and distribution of the oyster in America is from the pen of Capt. Broca, a French officer sent over some years ago by his government to investigate this subject. The work is being prosecuted in the Chesapeake Bay by the Coast Survey steamer *Palinurus*, Mr. H. J. Rice, formerly of Johns Hopkins University, looking more particularly after the natural history features, such as the embryology and development of the oyster, &c. After the survey and investigation have been completed in Chesapeake Bay, the exploration will be extended to other points on the coast. For the better purpose of furnishing the required data for a critical investigation of the subject, the party, in addition to determining the depth of water in which the beds are situated, will secure samples of the water itself, with specimens of the oyster, and the temperature and currents will be observed, the whole work being conducted in accordance with the best principles of modern research.

M. THIERS' long-talked-of work on philosophy will soon be published; it is in the hands of copyists, who will finish their work this week. The work will include scientific subjects. It will be published in three volumes, but the first is the only one which has been completed. The last two volumes have not been revised by the author. M. Thiers began the work in 1864, after having received lessons in astronomy from Leverrier and in chemistry from Sainte Claire Deville. It was interrupted from 1870 to May 24, 1874, when Thiers was obliged to resign the presidentship of the French republic. But it underwent some interruption from January, 1877, when the illustrious author was appointed by the Chamber of Deputies President of the Commission for the Reorganisation of the Army. At St. Germain, when he suddenly died, he was busy re-writing his second volume.

MR. HORMUZD RASSAM, we learn from the *Times*, who returned to England in July last, bringing with him a rich collection of Assyrian antiquities, the result of his last expedition to explore the ruins of Ancient Nineveh, is about to start upon a second and much extended tour of exploration. The expeditions of the late George Smith and other explorers during the last few years have been greatly impeded by the restricted nature of the firmans granted, and constant disputes were arising as to the area over which the firman extended. Mr. Rassam has succeeded in obtaining a series of sufficiently open permits to enable the new expedition to assume the nature of a roving exploring party. The new firman includes the whole of Mesopotamia, embracing the region around Mosul—that is, the sites of Nineveh, Kalakh, and the ancient city of Assur, the site of which is marked by the mounds of Kileh Shergat. A special firman has been obtained to enable Mr. Rassam to commence explorations in a hitherto untouched field—the districts of North-Eastern Syria. This region, the country which once formed the seat of the powerful Hittite kingdom, having for its capital the city of Carchemish, is as yet a *terra incognita* to explorers, and as its annals when discovered will form an important link in the chain of history which binds Assyria to the West, great results may be expected from Mr. Rassam's explorations in this district.

WE have on our table the following books:—"Pleasant Ways in Science," R. A. Proctor (Chatto and Windus); "Ancient History from the Monuments of Sinai," S. H. Palmer (S.P.C.K.); "Crystallography," H. P. Gurney (S.P.C.K.); "Bluthendiagramma," 1st and 2nd Parts, Dr. A. W. Eichler (Engelmann); "Studies from the Physiological Laboratory of University of Cambridge" (University Press).—London Science Class-Books (Longmans):—"Botany, Morphology, and Physiology," W. R. McNab; "Botany: Classification of Plants," W. R. McNab; "Hydrostatics and Pneumatics," P. Magnus; "Invertebrata and Vertebrata," Prof. Macalister; "Motion of the Moon," Dr. S. Newcomb (Washington); "Physical, Geological, and Geographical Map of Great Britain," Prof. Ramsay (Standford); "Meteorology of the Bombay Presidency," Charles Chambers; "Karl Ernst von Baer," Dr. Stieda; "Karl Friedrich Gauss, Hauptmann (E. J. Brill); "Report on Iron and Steel as Manufactured by Messrs. Jones and Laughlins," R. H. Thurston; "On the Equilibrium of Heterogeneous Substances," Parts 1 and 2, J. W. Gibbs; "Skizzen aus West Afrika," Oskar Lenz (A. Hofmann); "Les Produits de la Nature," A. J. C. Geertz (C. Lèvy); "La Prévision du Temps," W. de Fonvielle.

THE additions to the Zoological Society's Gardens during the past week include a Cross Fox (*Canis fulvus*) from Colorado, presented by Mr. Wilfred G. Marshall; a Common Otter (*Lutra vulgaris*), European, presented by Mr. W. H. Baylis; a Brown Mynah (*Acridotheres fuscus*), a Pied Mynah (*Sternopastor contra*) from India, an Indranee Owl (*Syrnium indranee*) from Ceylon, presented by Capt. J. Murray; four Egyptian Geese (*Chenalopex ægyptiaca*) from the Cape of Good Hope, presented by Mr. Justice Denyssen; two Leopard Tortoises (*Testudo pardalis*) from the Cape of Good Hope, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; a Collared Peccary (*Dicotyles tajaçu*) from South America, deposited; a Red-Sided Eclectus (*Eclectus polychlorus*) from Malacca, a Black-Footed Penguin (*Spheniscus demersus*) from the Cape of Good Hope, four Chinese Turtle-Doves (*Turtur chinensis*) from China, purchased; a Hybrid Mandrill Monkey (between *C. mormon* ♀ and *M. cynomolgus* ♂), an Indian Muntjac (*Cervulus muntjac*), born in the Gardens.

ON THE PRESENCE OF DARK LINES IN THE SOLAR SPECTRUM WHICH CORRESPOND CLOSELY TO THE LINES OF THE SPECTRUM OF OXYGEN[1]

THE measurement of the wave-lengths of the dark lines of the solar spectrum obtained by photographs, and the construction of a chart of the same, has for many years occupied my leisure time. As a result of the investigations connected with this work, I have arrived at the belief that oxygen as well as other non-metallic gaseous elements are represented in the solar spectrum by dark lines in the same manner as metallic substances. The lines in the case of oxygen are, however, very faint when compared with those produced by metals in the vaporous state.

The apparatus employed in these investigations may be briefly described as follows: 1st, a spectroscope for photographing the normal solar spectrum. As my purpose was to obtain photographs in which the positions of the lines should be as true as possible, I resorted entirely to the process by reflection, *and at no time did the solar rays pass through glass*; all error that might arise during refraction was thus avoided. The mirrors of the heliostat were of flat glass silvered, the silver-surface being polished served as the reflector. The surface of the concave-mirror employed to bring the image of the slit to a focus, was also silvered and polished. Gratings of 4,800 and 9,600 lines to the English inch, ruled on glass by a machine constructed by myself and by my assistant Mr. Sickels, and also an admirable one of 17,280 lines to the inch, for which I am indebted to Mr. Rutherfurd, were used. These were silvered with a thin coating, and the unpolished silver surface employed to give spectra by reflection. With the 4,800 line gratings the photographs were in the 1st and 3rd orders; with those of 9,600 lines in the 3rd order, and with 17,280 in the 1st and 2nd orders. The accuracy of the gratings was tested with satisfactory results by taking photographs in equivalent orders of spectra on each side of the normal. The photographs for the determination of the wave-lengths of the solar spectrum were in sections of eighty to one hundred and fifty wave-lengths. The gratings were adjusted to the line of no deviation for the centre of each section of the spectrum, as it was photographed.

The wave-lengths of the lines of the spectrum were carefully measured on the original photographs, by projecting them upon a scale of wave-lengths, each wave-length being five millimetres in extent. The scale was drawn upon slips of paper, which had been glued to strips of well-seasoned pine wood cut with the grain. The lantern used for projection was that described in this journal for April, 1878. The distance of the lantern from the scale, and the consequent magnifying power, was so adjusted as to make the leading lines of the photograph coincide with the same lines of Ångström, drawn in their proper position below the scale as is shown in the diagram given later on. Thus the positions of the lines in each section of one hundred or more wave-lengths were all made visible at once, and the errors in Ångström's chart corrected. From 4045 to 0 in the ultra-violet the leading lines of Cornu were employed. Among the advantages presented by this method of studying and measuring the lines of the spectrum we may mention the opportunity offered for several persons to inspect at the same time the details of the section under examination, and submit them to intelligent discussion. To this we may add the facilities offered for comparing many photographs with each other by marking below the scale the peculiarities of one, and then projecting the others in order upon the marks made. In this way the effects of duration of exposure and manner of development of the image, together with the variation in the size of the slit and focal distance may be investigated, and their action on the details of the picture determined. Pictures may even be placed face to face, one a little above the other, and examined in that position by projection. From the measures thus obtained a chart of the spectrum was constructed, which extended from E in the green to P in the ultra-violet. The values assigned to the wave-lengths in this chart are those of Ångström, and it is my purpose to present the positions and characters of certain of these lines in this communication.

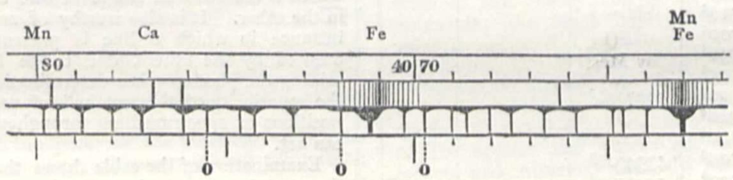
The great increase in the number of lines in the chart made from photographs by Mr. Rutherfurd's grating, compared with that of Ångström, led me to collect all the measurements of spectrum lines of elements that I could find, for the purpose of determining the character of the newly-measured lines. On comparing the lines of the spectra of oxygen, nitrogen, and air, as given in Watt's index of spectra, from the researches of Thalén, Huggins, and Plücker, I was struck with the number of approximate coincidences between the wave-lengths of oxygen lines and those of dark lines in my map. Attempting to make a close comparison of the oxygen with the solar lines I was confronted by the following difficulties, viz.: the measurements

[1] By John Christopher Draper, M.D., LL.D., Professor of Natural History in the College of the City of New York. From the *American Journal* for October.

of Thalén, Huggins, and Plücker were given in wave-lengths only, fractions being omitted altogether. Error amounting to half a wave-length could therefore exist in the position of a line, according as it fell on one side or the other of a figure on the scale expressing a wave-length. In the values given to the air-lines by Ångström in his chart, this difficulty did not exist; I therefore attempted the use of Ångström's values, employing the work of Huggins and Plücker, to separate as far as possible the oxygen from the nitrogen lines. This operation was, however, quickly discarded; because of the great differences existing between these authorities regarding the wave-lengths of a number of oxygen and air-lines. To obviate this trouble, I made photographic measurements of the lines of the electric spectrum of oxygen by the method detailed below.

The apparatus employed consisted of a spectroscope with two flint glass prisms of 60°, adjusted to the minimum deviation of D′. Collimator and telescope objectives, achromatics of ten inches focus. This was used to make photographs of the spectra given by the condensed electric spark in oxygen, in air, and in nitrogen. When so employed the eye-piece of the telescope was removed, and a camera placed in its stead. The slit was sometimes made as narrow as was possible. The induction-coil was one of Ritchie's, giving a ten-inch spark, and having a hammer current-breaker driven by clock-work. The battery was three two-gallon bichromate cells, the elements were large, but just touched the fluid when the battery was in operation. The large mass of fluid in proportion to the immersed area of the elements served to supply a very uniform primary current. The condenser on the secondary current consisted of ten glass plates, each having a tin-foil coating of thirty-six square inches. One or more of these plates could be thrown into the circuit as occasion required. By this arrangement a number of photographs of the electric spark, between platinum and iron points, in atmospheres of oxygen, and of oxygen and nitrogen, were made. The positions of the iron and oxygen lines in these were measured, as in the solar photographs, by projection under a suitable magnifying power. The centre of each line was the portion from which measures were taken in all cases. The wave-lengths of the oxygen-lines were then determined by means of a curve, which from λ3864 to λ4414·75 was based on the iron lines of the same spectrum. In all forty-seven iron lines in this extent of the spectrum, or about one to every eleven wave-lengths were used. The values assigned to the iron lines were those obtained in my chart of the solar spectrum. By this method of measurement errors arising from maladjustment of two spectra were avoided. From λ4414·75 to λ4705 the iron lines did not photograph; I was therefore obliged to construct this portion of the curve from the wave-lengths of oxygen and air-lines already given by various authorities, selecting those values in which they agreed. From 3864 to 4414·75 the results are therefore accurate. From 4414·75 to 4705, though they are approximate, the error, if any exists, must be very small. The measurements to fractions of a wave-length were obtained by constructing the curve on a scale of sufficient magnitude.

In illustration of the great number of lines presented by my chart of the solar spectrum, as compared with that of Ångström, I give a small section extending from 4062 to 4080, within which the oxygen group 4069·80—4072·10—and 4075·50 falls. On the upper part of the diagram the symbols of the elements are placed, to which, according to Ångström, corresponding lines are found in the solar spectrum. On the first space below the line is the scale of wave-lengths, each wave-length being five millimetres in extent. In the second space the lines of Ångström's chart are given. In the third space the lines measured on the photographs, the vertical portion of each symbol giving the position, and the horizontal portion the width, and also the darkness on an arbitrary scale of one to ten. The darkest lines encroach most on the vertical portion of the symbol. The value 10 is expressed in the symbol of the Mn Fe line 4063, and the value 1 in that of the line 4068·05. Other features of the lines are shown by the manner in which the upper part of each of these symbols is drawn. Beneath the spectrum-lines the scale is repeated, and the position of the



oxygen lines indicated. In addition to the lines already mentioned as being in Ångström's chart, lines of the following elements appear in this space, viz., Fe 4063, Pb 4066, Sr 4078, Bi 4080. The correspondence between these values and the wave-lengths of the lines in the photographic spectrum is as close as could be expected, seeing that the authorities do not give fractions of wave-lengths. The Te line is represented in the spectrum by the Mn Fe line 4063, the Pb line by the spectrum line 4065·7, the Sr line by the line 4077·9, and the Bi line by the line 4079·8.

Inspection of the diagram also shows that, while the Mn Fe 4063 lines are coincident in both charts, the Fe line 4071 of Ångström reads 4071·25 in the photographic chart, and the unassigned line 4076·25 of Ångström reads about 4076·20, in my chart, the two lines being nearly coincident. In the photographic chart the relations of the lines to each other as regards position are accurately presented, and where these differences occur the positions given in the photographic chart must be correct. The total number of lines in the two charts is also worthy of notice. In the eighteen wave-lengths represented in the diagram Ångström gives six lines, while the photographic chart gives twenty-four. Of Ångström's lines five are assigned to different metals, if we give the line 4066·25 to Pb, and one is unassigned. In the photographic chart these lines also appear, and in addition the lines of Bi and Sr, together with the three oxygen lines. Out of the twenty-four lines ten are assigned to various elements, leaving fourteen to be accounted for, and many of these are moderately strong lines. The oxygen lines represented in the diagram are among the strongest in the electric spectrum of oxygen, yet the equivalent lines in the solar spectrum are faint when compared with the lines of Ca and Fe. This would seem to indicate a low absorbing power in the gaseous non-metallic elements, as compared with the same power in the case of metals in the vapourous state. The existence of a difference like this would explain why it is that many of the lines in the solar spectrum which represent oxygen have been overlooked. Some of these lines have, however, been observed, Ångström himself giving in his chart a number of lines not assigned by him nor any one else to other elements, which are very nearly coincident with the oxygen lines, as determined by the photographic method, as will be seen in the table at the close of this article.

As it is not possible, in the space to which we are limited, to give diagrams of all the portions of the solar spectrum which contain oxygen lines, we present in the following table the positions in that spectrum of all the oxygen lines that were obtained in the photographs of the electric spark in that gas. The first column contains the wave-lengths of certain lines in the chart made from photographs of the solar spectrum; the second the wave-lengths of the lines of the condensed electric spark in oxygen; the third Plücker's lines of oxygen, which are much more numerous than those of Huggins, which are presented in the fourth column, while the fifth column gives the lines of Ångström's air spectrum, which may be credited to oxygen. The term free in the first column is used to indicate the fact that no element has heretofore been found to give a line within two or three tenths of a wave-length of that position. It is therefore free to be assigned as an oxygen line. The chemical symbols on the other lines show that the element indicated has been assigned to that line, and shares it with oxygen. The number of lines of greater wave-length than 3961·60, which are free from other elements, and which are assignable to oxygen, is good evidence of its presence in the solar envelopes.

DRAPER. Lines of photographic chart of solar spectrum, with their condition.	DRAPER. Lines of electric spark in oxygen.	PLÜCKER. Lines of oxygen.	HUGGINS. Lines of oxygen.	ÅNGSTRÖM Lines of spark in air attributed to oxygen.
3864·50^{2} free.	3864·75^{1}			
3882·30^{9} ,,	3882·30^{3}			
3907·90^{2} ,,	3908·00^{1}			
3912·25^{3} ,,	3912·35^{3}			
3919·75^{3} ,,	3919·50^{2}			
3945·10^{1} ,,	3945·10^{3}			
3954·60^{3} ,,	3954·70^{7}			
3961·60^{4} ,,	3961·60^{2}			
3973·40^{3} ,,	3973·50^{10}			
3982·75^{1} ,,	3982·70^{3}			
3995·50^{3} ,,	3995·50^{5}			
4069·80^{2} ,,	4069·50^{10}	4069·00^{3}	4069·00^{3}	4069·50
4072·10^{3} ,,	4071·90^{10}	4072·00^{3}	4073·00^{3}	{4071·65 4073·65
4075·50^{2} ,,	4075·45^{10}			4075·50
4084·70^{4} ,,	4084·80^{5}	4085·00^{4}		
4088·00^{1} ,,	4087·80^{4}	4086·00^{2}		
4093·20^{1} ,,	4093·10^{4}	4094·00^{2}		
4104·40^{2} ,,	4104·50^{6}	4104·00^{2}		4103·00
4111·00^{2} ,,	4111·10^{4}			
4118·00^{7} Fe.	4118·20^{10}	4117·00^{2}	4117·00^{2}	
4121·20^{3} ,,	4121·20^{6}			
4133·00^{3} free.	4132·90^{6}	4126·00^{6}		
4142·90^{7} Fe.	4142·90^{6}	4135·00^{6}		
4145·30^{2} free.	4145·50^{7}	4147·00^{2}	4149·00^{2}	
4152·90^{1} ,,	4153·00^{8}			
4155·60^{1} ,,	4155·75^{4}	4158·00^{4}		4155·00
4168·20^{1} S.	4168·40^{4}	4171·00^{2}		
4184·90^{1} free.	4185·00^{8}		4183·00^{5}	4184·50
4189·90^{1} C.	4190·00^{10}	4190·00^{5}		4189·60
4254·30^{1} free.	4254·50^{3}			
4274·80^{4} CrCa.	4275·00^{6}			
4278·10^{3} Pb.	4278·10^{6}			
4303·00^{5} free.	4303·00^{4}			
4316·60^{2} ,,	4316·50^{8}			
4320·00^{4} TiC.	4319·75^{8}			
4325·10^{10} Fe.	4325·20^{6}	4327·00^{2}		
4328·10^{1} Bi.	4328·20^{4}			
4331·00^{2} free.	4331·20^{4}			
4336·34^{4} SCr.	4336·00^{6}	4334·00^{2}		
4345·15^{2} free.	4345·20^{9}	4341·00^{6}		4345·80
4348·20^{2} ,,	4348·30^{10}	{4347·00^{10} 4348·00^{10}	4347·00	4347·50
4353·00^{2} ,,	4553·10^{8}			
4365·00^{1} BrCe.	4365·20^{8}		4364·00^{4}	
4369·10^{4} CrFeAs.	4369·20^{4}	4369·00^{4}		
4394·50^{3} free.	4394·50^{4}			
4413·20^{2} ,,	4413·20^{10}	4414·00^{8}	4414·00^{8}	4414·60
4417·85^{3} ,,	4418·00^{10}	4418·00^{8}	4416·00^{8}	4418·30
4445·00^{2} ,,	4445·00^{6}	4443·00^{4}		
4450·00^{2} Mn.	4450·00^{3}	4450·00^{4}		
4463·00^{2} Ce.	4463·00^{8}	4457·00^{4}		
4467·30^{1} Ce?	4467·20^{8}	4468·00^{10}	4467·00^{10}	
4483·80^{1} Fe.	4483·75^{3}	4474·00^{10}		
4572·10^{3} Be.	4572·20^{1}			
4577·75^{6} Ce.	4577·55^{1}			
4582·10^{2} FeCe.	4582·10^{1}			
4589·30^{4} free.	4589·50^{10}		4588·00^{6}	4590·80
4595·40^{3} ,,	4595·50^{10}	4593·00^{6}	4596·00^{6}	4595·90
4599·80^{3} 4600·15^{4} { Sb. C.P. Cr.	4600·00^{3}	4600·00^{6}		
4629·60^{3} free.	4629·60^{4}	4639·00^{10}		
4640·50^{3} ,,	4640·20^{10}	4640·00^{10}	4640·00^{6}	4640·25
4648·15^{4} Cr.	4648·15^{10}	4649·00^{8}	4648·00^{8}	
4661·50^{4} free.	4661·50^{8}	4662·00^{7}	4662·00^{7}	
4674·90^{1} CSe?	4675·00^{8}	4675·00^{7}	4677·00^{7}	4674·75
4698·65^{3} free.	4698·50^{10}	4698·00^{7}	4699·00^{7}	4698·00
4704·65^{1} Ba.	4705·00^{10}	4705·00^{7}	4706·00^{7}	4706·50

The table presents what may be called the oxygen region of the spectrum, only a few oxygen lines lying outside of its limits. As this also happens to be the region in which our photographic apparatus and chemicals were most sensitive, we are enabled to present measurements of the majority of the lines of oxygen. It will be noticed that though the oxygen lines of greater wave-length than 4704·65 are wanting, on account of their lack of photographic power, this loss is partly made up by the extension of the measurements into the ultra-violet region, where as yet no exact measurements of oxygen lines have been made that I am aware of.

That there should be no error regarding the nature of the chemical element producing the lines, every precaution was taken to have the oxygen as pure as possible. Photographs of the spark in oxygen, between points of the purest platinum that I could procure, were also made. These were compared with the measured photographs of the spark between an iron and a platinum terminal, and provision was thus made for the detection of any error that might have arisen from impurity in the iron used in the terminal. As these photographs of the spark between platinum terminals in pure oxygen presented all the lines given in the table, these lines may be regarded as true oxygen lines. In addition to the oxygen lines given, the following feeble lines were observed, regarding the nature of which I was not quite satisfied, as they did not pass entirely across the spectrum, viz., 4490·30—4505·80—4525·50—4548·75. In the space extending from 4254·30 to 4345·15, many of the oxygen lines are assigned to wave-lengths occupied by other elements; for example, Cr, Ca, Sb, Ti, C, Bi. As other lines of these elements did not present themselves in the measured photographs, and as the lines in question were also found in the photographs of the spark between platinum terminals, they are to be regarded as true oxygen lines, although they are not given by other authorities. In some of the instances in which elements in addition to oxygen are assigned to a weak line in the solar spectrum, it is very possible that such assignments are in error, because of a lack of fractions in the determinations of the wave-lengths of these additional elements. Apparent discrepancies regarding wave-lengths in my determinations, and those of the other authorities, are sometimes explained by the fact that a line which is recorded as single in one case, is given as two lines in the other. It is also worthy of remark that in almost every instance in which a line is presented by one authority and omitted by the others, it is to be found in the column containing the photographic determinations, and is an evidence of the superiority of this method of recording the existence and positions of spectrum lines throughout the region over which it can act.

Examination of the table shows that the differences between the wave-lengths obtained for the lines of the electric spectrum in oxygen and the lines of the solar spectrum are very small. Out of the sixty-five lines of the solar spectrum which are, as we have seen, assignable to oxygen, in seventeen the coincidences are absolute; in four the difference is only five one-hundredths of a wave-length; in twenty-two, ten one-hundredths of a wave-length; in four, fifteen one-hundredths of a wave-length; in eleven, twenty-one one-hundredths of a wave-length, and in the remainder the greatest difference is only thirty-five one-hundredths of a wave-length, or about that which Ångström has made in different measurements of the same line in the solar spectrum.

The small figure attached as a power to each wave-length of the electric and solar spectra in the table is a proximate expression of the photographic strength of that particular line in each spectrum, and an examination of these upholds the statement made in a preceding paragraph that the oxygen lines of the solar spectrum are very weak when no other element furnishes a line which falls on the same wave-length. Of course photographic must not be compared with visual intensities, for as the one diminishes in the less refrangible regions of the prismatic spectrum the other increases. An example of coincidence in the lines of different elements, and consequent increment in strength, occurs in the line 4118, and probably in the line 4303 also, though it is supposed to be free.

In conclusion, I give a list of certain lines in Ångström's chart which have not as yet been assigned to any element, together with the wave-lengths of the same lines in my solar and electric spectra. From this table it will be seen that Ångström himself observed a number of lines, the relations of which to elementary bodies no one has as yet demonstrated, and which I believe represent the oxygen in the solar envelopes.

Table of Free Lines in Ångström's Solar Spectrum which may be attributed to Oxygen.

Draper's electric spectrum of oxygen.	Draper's solar spectrum.	Ångström's solar spectrum.
$4132{\cdot}90^{6}$	$4133{\cdot}00^{3}$	$4133{\cdot}20^{2}$
$4155{\cdot}75^{4}$	$4155{\cdot}60^{1}$	$4155{\cdot}80^{2}$
$4254{\cdot}50^{3}$	$4254{\cdot}30^{1}$	$4254{\cdot}55^{3}$
$4303{\cdot}00^{4}$	$4303{\cdot}00^{5}$	$4303{\cdot}00^{2}$
$4316{\cdot}50^{8}$	$4316{\cdot}60^{2}$	$4316{\cdot}50^{2}$
$4348{\cdot}30^{10}$	$4348{\cdot}20^{2}$	$4347{\cdot}95^{1}$
$4394{\cdot}50^{4}$	$4394{\cdot}50^{3}$	$4394{\cdot}45^{2}$
$4595{\cdot}50^{10}$	$4595{\cdot}40^{3}$	$4595{\cdot}20^{2}$
$4648{\cdot}15^{10}$	$4648{\cdot}15^{4}$	$4648{\cdot}75^{4}$
$4661{\cdot}50^{8}$	$4661{\cdot}50^{4}$	$4661{\cdot}70^{2}$

The subjects presented in this communication may be briefly summed up as follows :—

1. The resort to the process of reflection in producing and photographing solar spectra, and thereby avoiding certain errors, and the employment of the silvered surface itself of a glass grating.

2. The extension of the measurement of oxygen lines into the ultra-violet region.

3. The measurement in the region of less refrangibility than H, of lines of oxygen not heretofore recorded, and the use of projection as a method of measurement.

4. The establishment of a close relationship in position between certain lines in the solar spectrum and the lines of oxygen; the slight differences that exist being assignable to the experimental difficulties in the way of making accurate measures of the oxygen lines, and falling within the limits of error of experiment.

5. The evolution of the fact that the lines of the solar spectrum which appear to correspond to the lines of oxygen are weak, or faint, and show that that gas possesses a feeble absorbent power when compared with metallic vapours or gases like H, Fe, Ca.

6. The demonstration that in Ångström's chart there are many lines not assignable to any elementary body, and that these lines occupy very closely the positions of certain oxygen lines.

7. The suggestion that the proof of the presence in the solar envelopes of oxygen, and other substances giving faint lines, is a problem not to be solved by the comparison of two spectra of small dispersion. The solar spectrum in certain parts is so crowded with lines presenting all kinds of details, that the only satisfactory way is to make measures of the positions of these lines on a large scale, and as truly as possible, and then compare with these the most accurate measures of oxygen lines that can be made.

CYON'S RESEARCHES ON THE EAR [1]

II.

HAVING now described, at what we hope our readers will not consider inordinate length, the history of the subject up to the time when Dr. de Cyon commenced his second series of experiments, a history which he gives in the first part of his thesis in a very clear and impartial manner, we shall now give a short account of the new matter contained in the second part. This may be arranged under two heads—(1) experiments undertaken chiefly with the view of testing the kinetic theory, and (2) the statement of his own theory and arguments in support of it.

The experiments have obviously been made with extraordinary care and skill. Dr. de Cyon succeeded in producing the lesions which he intended to produce, without injuring any other part, and in most cases with scarcely any loss of blood; we can thus observe the effects of any particular operation without the slightest complication from concurrent injury or inflammation of the cerebellum. He has established in the most convincing way, (1) the fact observed by Flourens that the movements of the head always take place "in the plane of the divided canal," or, as we should express it, about an axis at right angles to that plane. (2) That the movements are much more violent, and that the loss of equilibrium is much more persistent, when the corresponding canals of both sides are cut, than when one only, or two dissimilar canals are divided. (3) That when all six canals are destroyed very violent and complex convulsions occur and continue for several days. If the animal survive this stage it gradually attains a condition in which its movements are effected with great deliberation, and in which the sense of sight is absolutely necessary to enable it to direct itself. These experiments were made upon pigeons, upon rabbits, and upon lampreys, the latter animals being especially interesting as possessing only four canals, two on each side.

So far, the results of the new experiments confirm and render more precise the knowledge derived from previous investigations, and they are in perfect accordance with the kinetic theory. One point, however, requires special notice.

Dr. de Cyon points out that the first movement made by an animal on the section of a canal, takes place in a direction "from the divided canal." It is not quite easy to make out the precise meaning of this phrase. It may, and probably does mean, that when the *left* horizontal canal is cut the pigeon moves its beak to the right; but, as the operator is at the back of the bird, it may also mean that the *back* of the head moves to the right and away from the divided canal. Judging, however, from the experiments upon the vertical canals, it is most probable that Dr. de Cyon means that the first movement takes place in such a manner that the ampulla of the divided canal precedes the canal. If this be the case, and if, as seems reasonable, we assume that the first effect of the division is stimulation and not paralysis, and that the movement is a compensatory one—that is, the result of an effort to preserve the same position—we are forced to the conclusion that the canal is affected by a rotation in which the ampulla *follows* the canal, contrary to the view somewhat hesitatingly expressed by Brown and Mach.

Dr. de Cyon has, however, made several experiments, the results of which cannot so easily be harmonised with the kinetic theory. These experiments were made expressly to test the truth of this theory, and in his opinion their results render it untenable. As Mach holds that change of pressure in the ampullæ excites the ampullary nerves and produces a sensation of rotation, Dr. de Cyon devised and executed a series of experiments so arranged that the pressure in the ampullæ should be changed, without injury to the membranous canals. 1. He opened the bony canal and allowed the perilymph to escape. 2. He opened the utricle and allowed the endolymph to escape, and observed that the whole membranous labyrinth collapsed. 3. He introduced into the space containing the perilymph small rods of dried laminaria; these rods slowly swelled by imbibing moisture, and must have considerably increased the pressure in the interior of the cavity. In none of these cases did he observe any trace of the Flourens phenomena. 4. He replaced the perilymph by a lukewarm solution of gelatine, which solidified, and inclosed the membranous labyrinth in an approximately rigid case. Still no Flourens phenomena were observed, but these at once occurred on pricking the membranous canals through the solid gelatine.

Dr. de Cyon further mentions as an argument against Mach's view, the fact that periodic changes of pressure occur in the contents of the labyrinth, synchronous with the heart's beat, and evidently connected with the change of arterial pressure. This, he thinks should, on Mach's hypothesis, produce irritation of the nerves and sensation. It must, however, be observed, that this change of pressure is produced simultaneously in all the six ampullæ, and that therefore the resultant rotation perceived would be zero.

But by far the most important evidence in opposition to the kinetic theory is derived from the section of the whole auditory nerve. Dr. de Cyon succeeded in performing this operation without serious injury to any other part, and found that rabbits, in which both of the auditory nerves had been divided, and in which, therefore, all nervous connection between the semicircular canals and the brain had been cut off, showed, after being subjected to rotation, the same symptoms of vertigo observed by Mach in the case of normal rabbits. It is unfortunate that Dr. de Cyon has not given further details of this most important experiment.

External irritations which, when small, are perceived only by the organs specially fitted for their perception, as a rule act, when very intense, upon other organs. Thus a feeble sound can

[1] Recherches expérimentales sur les Fonctions des Canaux semi-circulaires et sur leur Rôle dans la Formation de la Notion de l'Espace. Par Elie de Cyon, M.D., &c., Lauréat de l'Institut de France. Continued from p. 635.

only be heard, a small quantity of an odoriferous substance can only be smelled, a dilute solution of a sapid substance can only be tasted, but a very loud sound can be felt by producing vibrations sensible to the nerves of the skin; ammonia gas attacks the mucous membrane of the nose, and mustard bites the tongue. These are not sensations of hearing, smell, or taste, but they are sensations produced by external irritations which, when feebler, are perceptible by these special senses only. It is not, then, unreasonable to suppose that sudden and violent changes of rate of rotation should be perceived by the shock communicated to all the soft and movable parts of the body, although slighter changes may be perceptible only by the special organ of the sense of rotation. The experiment just mentioned is undoubtedly a crucial one, but, in order to obtain from it a decisive answer, it would be necessary to make a series of comparative trials, with varied rates of rotation, upon normal rabbits, and upon rabbits whose auditory nerves had been divided; if no difference is observed, even with moderate change of rate, the kinetic theory must be abandoned.

A great deal of valuable information might be obtained by carefully testing the delicacy and accuracy of the sense of rotation in deaf-mutes. Many deaf-mutes have not only the cochlea, but the whole internal ear, destroyed; if, then, the inmates of deaf and dumb establishments were systematically tested by means of such experiments as Mach and Brown made upon themselves, experiments which would, no doubt, greatly interest and amuse them, and if the condition of the internal ear were, in each case of *post-mortem* examination of a deaf-mute, accurately noted, we should soon obtain a mass of information which would do more to clear up the relation between the sense of rotation and the semicircular canals than any number of experiments on animals unable to describe to us their sensations.

We cannot pass from this criticism of the kinetic theory without noticing a passage in Dr. de Cyon's thesis which seems to show that he has not fully appreciated the bearing of this theory:—"Quelques mots seulement pour mieux faire ressortir l'invraisemblance *à priori* de la théorie de MM. Mach, Crum Brown et d'autres. Comment admettre que les canaux semi-circulaires servent à nous informer sur la rotation de la tête, quand nous voyons les mêmes organes parfaitement bien développés chez les animaux qui, comme les grenouilles ou les poissons, ont la tête presque immobile et qui d'ailleurs, pas plus que les autres animaux, n'exécutent pas habituellement des mouvements de rotation?

"Pourquoi justement la présence d'un organe des sens pour un mouvement peu habituel et pas pour beaucoup d'autres, pour les mouvements que les animaux exécutent continuellement?"—P. 47.

No doubt a frog or a fish cannot move its head freely without at the same time moving its body, but head and body together move and perform frequent and rapid rotations. Whenever a fish or other animal changes the direction of its motion, rotation takes place, and a knowledge of the amount and of the axis of this rotation is necessary if the animal is to retain any sense of its orientation. Of all animals a fish, moving and turning with great rapidity and sharpness in a dense medium often affected by complicated currents, seems to have most need of such an organ which serves the same purpose as a ship's compass, an instrument surely not useless because a ship is rigid and does not habitually perform movements of rotation.

We have already alluded to some of the phenomena of optical vertigo. This subject is discussed at considerable length by Dr. de Cyon, and it is therefore right that we should here explain somewhat fully the opinions held in reference to it by various experimentalists.

The phenomena themselves are, in the main, well known. If we rotate about a vertical axis either actively (that is turning ourselves) or passively (that is being turned round on a movable chair or platform by an assistant) we are at first fully aware that we are turning and that external objects are at rest; gradually external objects seem to move round us in a sense opposite to that of our real motion. If at this stage we stop we not only feel that we are being turned round in the opposite sense to that of the previous real motion, but we see, or think we see, external objects turning round. These two imaginary rotations, viz., that of our body which we feel, and that of external objects which we see, take place about the same axis, in the same sense and at the same rate. The axis is parallel to the line in the head which was the axis of the original real rotation, and the sense is, as already explained, contrary to that of the original rotation. These facts are well known and were fully described by Darwin in the "Zoonomia" and by Purkinje. Another phenomenon closely connected with them was first noticed by Purkinje, and has since been investigated by Breuer and by de Cyon. When a real rotation of the body takes place the eyes do not at first perfectly follow the movement of the head. While the head moves uniformly the eyes move by jerks. Thus, in the diagram, Fig. 3, where the abscissæ indicate time and the ordinates the angle described, the straight line *a b* represents the continuous rotatory motion of the head and the dotted line the discontinuous motion of the eye.

Here it will be seen that the eye looks in a fixed direction for a short time, represented by one of the horizontal portions of the dotted line *a b*, and then very quickly follows the motion of the head, remains fixed for another short time, and so on. After the rotation has continued for some time the motion of the eye gradually changes to that represented by the dotted line *c d* in Fig. 4. The eye now never remains fixed, but moves for a short time more slowly than the head, then quickly makes up to it, then falls behind, and so on. At last the discontinuity of the motion of the eye disappears, and the eye and head move together.

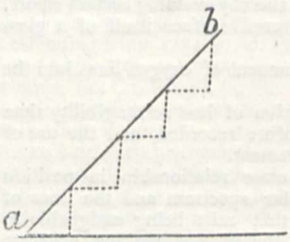


Fig. 3.

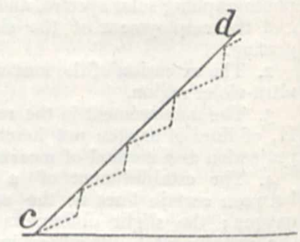


Fig. 4.

If now the rotation of the head be stopped (of course the body stops also) the discontinuous movements of the eyeballs recommence. They may now be represented by the dotted line in Fig. 5.

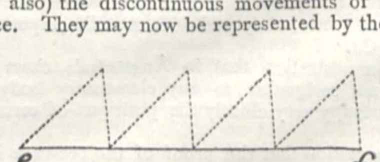


Fig. 5

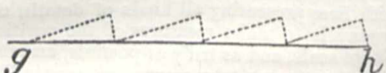


Fig 6.

The intermittent motion of the eyes gradually becomes less, passing through a condition such as that shown by the dotted line in Fig. 6, and at last ceases. The consideration of these oscillatory motions is greatly simplified if we draw diagrams similar to the above, but in which $\frac{dy}{dx}$ is made proportional to the *apparent* rate of rotation, that is, to the rate of rotation as perceived by the observer, instead of to the real rate as measured or inferred from external observations.

The *apparent* motion of the head and of the eyeballs is shown in Fig. 7 when uniform real rotation is kept up until it ceases to be perceived, and is then suddenly stopped.[1] The accented letters a', b', &c., correspond to a, b, &c., in Figs. 3, 4, 5, and 6.

We now see what is the real nature of the oscillatory movements. The eye remains for a short time in an apparently fixed

[1] In order to represent accurately the phenomena, the oscillations should be much more numerous and of course smaller. As five or six complete turns are required before all sense of rotation is abolished, and as Dr. Breuer finds at least ten oscillations in one complete turn, there should be at least fifty between a' and e'. These could not be represented without making the figure either very large or very indistinct. Such diagrams are not used by any of the physiologists who have investigated the subject, and must not be interpreted too rigidly, as both the duration and the extent of the oscillations vary considerably. The figures, however, represent the general nature of the phenomena sufficiently for our purpose.

direction, that is, in a direction which the experimenter, judging from his sensation of rotation, concludes to be fixed, then rapidly returns to its original position relatively to the head, again for a short time looks in an apparently fixed direction, and so on.

Some physiologists have considered these oscillatory movements as the cause; others—and notably Dr. de Cyon—regard them as the effect, of the visual vertigo. The latter opinion seems the more reasonable; and indeed both visual and tactile vertigo seem to be matters of judgment rather than of sensation. When the real rotation stops the experimenter perceives, by his sense of rotation, that his head is turning round; he *feels* that his body and the chair on which he sits are at rest rela-

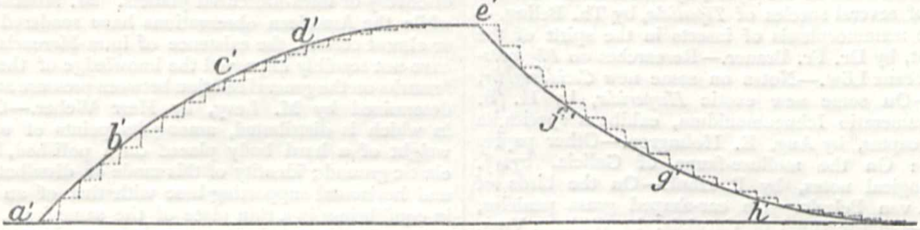


Fig. 7.

tively to his head; he *sees* that external objects are at rest relatively to his head; and he concludes that, as his head is turning round, his body, his chair, and all external objects must be turning round also—his eyes oscillate precisely as they would do if all these imaginary rotations were real.

Similar oscillatory movements of the eyeballs are described by Dr. de Cyon as resulting from the section or mechanical irritation of the semicircular canals in rabbits, and are by him referred to reflex action dependent on intimate anatomical connection between the roots of the nerves of the ampullæ and those of the motor nerves of the eye. The points of chief importance noticed by him are:—

1. At the moment of irritation the spasm of the muscles of the eyeballs has a tetanic character; immediately afterwards the oscillations commence, and last for a variable time, depending on the intensity of the irritation, and rarely exceeding half-an-hour. The frequency of the oscillations varies from 20 to 150 per minute.

2. The direction of the oscillations depends on the particular canal cut or irritated. Dr. de Cyon describes, somewhat minutely, the direction in each case, but states that he finds it difficult, on account of the peculiar position of the eyes in the rabbit, to give a precise determination of these directions. From his descriptions we can, however, gather, with considerable probability, that the eyeballs oscillate about an axis perpendicular to the plane of the divided or irritated canal.

3. The oscillations, caused by the irritation or section of any one canal, cease when the opposite auditory nerve is divided; new irritations of the canal then produce only tetanic contractions.

The direction of the initial tetanic spasm is given by Dr. de Cyon, and appears to coincide with what we should expect if rotation with the ampulla *preceding* be supposed to excite the ampullary nerves; this result leads to the suspicion that we may have misinterpreted the author's account of the initial movement of the head on section of one canal in the pigeon.

We have now only to state and examine Dr. de Cyon's theory of the function of the canals and of the part which they take in the formation of the idea of space.

This theory is stated in a very general form, and it is difficult by a single quotation to do full justice to it. We quote, however, two passages in which it is distinctly enunciated, and refer the reader for its full discussion to the thesis itself:—

"Les canaux semi-circulaires sont les organes périphériques du sens de l'espace; c'est-à-dire que les sensations provoquées par l'excitation des terminaisons nerveuses dans les ampoules de ces canaux servent à former nos notions sur les trois dimensions de l'espace. Les sensations de chaque canal correspondent à une de ces dimensions.

"A l'aide de ces sensations, il peut se former dans notre cerveau la représentation d'un espace idéal sur lequel seront rapportées toutes les perceptions de nos autres sens qui concernent la disposition des objets qui nous entourent et la position de notre corps parmi ces objets."—P. 64.

"La disposition des nerfs, dans trois plans perpendiculairs l'un à l'autre, se prête à merveille pour une pareille fonction. Nous pouvons très bien nous figurer comment les sensations d'etendue, dans trois plans, dont la disposition, chez tous les vertébrés, répond exactement aux trois co-ordonnées de l'espace, peuvent être utilisées par notre intelligence pour la construction d'une notion de l'espace.

"Je dirais plus: aucun autre sens ne présente une relation aussi facile à saisir entre la représentation et la sensation, que le sens d'espace, d'après ma manière de voir."—P. 73.

This is not inconsistent with the kinetic theory as explained above. The difference is that that theory does, and Dr. de Cyon's does not, explain what the sensations of the canals are and how they contribute to our ideas of direction or orientation in reference to three rectangular axes.

There are two ways in which we may investigate the action of an organ of sense:—We may examine and compare the information we obtain by means of the sense under a great variety of conditions; this is the way in which our knowledge of physiological optics has been chiefly obtained: or we may study the effects of injuries of the organ, either occurring naturally or intentionally produced. A detailed theory has, in the case before us, been sooner attained by the first of these ways than by the second. This theory must be tested by experiments carried out in every appropriate way, and, if necessary, must be modified in accordance with their results. We may thus expect to obtain a knowledge of the mechanism of the sense of orientation as complete as that which we have of the mechanism of the sense of sight. Dr. de Cyon's thesis contains the record of a very considerable step in this direction.

ALEX. CRUM BROWN

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE President and Fellows of St. John's College, Oxford have just passed the following resolution *nem. com.*: "That independently of the granting of Fellowships for the assistance of research, the college shall from time to time make money grants for that purpose." The granting of Fellowships alludes to a clause in the new Statutes which has just been drafted, in which a Fellowship is set apart for this purpose.

PROF. HUXLEY will lecture at a general meeting of the Working Men's College, Upper Kennington Lane, to be held on the 24th, at 8.30 P.M., to inaugurate the new premises of the College, near Vauxhall Station, one part of which has been fitted up as a chemical laboratory, with all the appliances needed for the study of practical chemistry.

THE New South Wales correspondent of the *Colonies* states that, in consideration of the necessity which is now felt for extending the curriculum of Sydney University and augmenting its teaching powers, the Colonial Government have consented to ask Parliament for an additional annual grant of 5,000*l*. This will enable the Senate to make the following additions to the present course of study:—(1) Mental philosophy, law, history, and English literature; (2) all the education necessary for the medical profession; (3) a complete course of natural philosophy, coupled with mechanics and engineering; (4) the addition of organic chemistry and metallurgy to the chemical school; and (5) biology, including animal and vegetable physiology. The Senate will also be in a position to establish a faculty of science, and to confer the degrees of Bachelor and Doctor of Science, and also degrees in medicine, on those who have received their education in Sydney.

SCIENTIFIC SERIALS

Verhandlungen der k.k. zoologisch-botanischen Gesellschaft in Wien (vol. i. 1878).—This volume is in every respect equal to its predecessors, both for variety as well as scientific interest of its contents. The papers which deserve special praise are: Lichenological excursions in the Tyrol, by F. Arnold.—On the metamorphosis of several species of *Tipulidæ*, by Th. Beling.—Remarks on the metamorphosis of insects in the spirit of the theory of descent, by Dr. Fr. Brauer.—Researches on *Phytoptocecidiæ*, by Dr. Franz Löw.—Notes on some new *Cecidomyidæ*, by the same.—On some new exotic *Hesperidæ*, by H. B. Möschler.—Ennumeratio Ichneumonidum, exhibens species in alpibus Tiroliæ captas, by Aug. E. Holmgren.—Other papers of interest are: On the mollusc-fauna of Galicia, by J. Król.—Ornithological notes, by P. Hanf.—On the birds of Ecuador, by A. von Pelzeln.—On ear-shaped grass panicles, by E. Hackel.—On the fungi of Carniola, by Wilhelm Voss.—Note on a new mollusc, by M. Folin.—On some new *Cucujidæ* in the Royal Museum at Berlin, by Edmund Reitter.—Researches on *Lyctidæ*, by the same.—Analytical classification of the species in the genera *Sphindus* and *Aspidophorus*, by the same.—On the influence of changes in the conditions of vegetation upon the forms of the organs of plants, by Otto Stapf.—On a remarkable form of Lenticels, by the same.—On some species of the *Chalcidiæ* genus *Eurytoma*, obtained by artificial breeding, by Dr. G. Mayr.—On the flora of Fiume, by A. M. Smith.

SOCIETIES AND ACADEMIES

London

Royal Microscopical Society, October 9.—H. J. Slack, president, in the chair.—This was the first meeting of the present session. Numerous presents were announced and acknowledged, and Major Festing and John Borland were elected Fellows of the Society.—The president called attention to a specimen of the perforating proboscis of a moth which had been received from Colombo, and compared its structure with that of a species which had been the subject of discussion at a former meeting.—An interesting paper was read by Prof. Owen upon certain fossils found in the middle Purbeck, to which he had given the name of *Granicones*, and which, after careful comparative examination, he had decided to be the dermal scutes of a lacertian closely resembling the now existent Australian species, *Moloch destructor*. He pointed out that the remains found in these rocks were chiefly those of marsupials, and that in the mesozoic strata both animals, plants, and shells had now their only living representatives at the antipodes.—Communications were read from Col. Woodward on the modification of the illuminator for balsam-mounted objects, also from the American Microscopical Congress recommending the adoption of the $\frac{1}{100}$ millimetre as the standard for microscopical measurements.—A discussion ensued, in the course of which it was suggested that much advantage would arise to microscopists from the more careful adherence on the part of makers to the Society's standard screw, and also greater uniformity as to size of tube, eye-pieces, and other mechanical details.

Paris

Academy of Sciences, October 7.—M. Fizeau in the chair.—The following papers were read:—On the irreducible covariants of the quantic of the seventh order, by Prof Sylvester.—Observations on M. Gruey's recent communication on a gyroscopic apparatus, by M. Hirn. He considers the new apparatus presents a special case of phenomena analysed in his own memoir on the gyroscope.—On a singular case of heating of a bar of iron, by M. Hirn. A workman holding a cylindrical iron bar (about 1 m. long and 0·08 in diameter) on another piece so as to be struck with a hammer on the free end, said he felt the bar at each stroke greatly heated and then as quickly cooled. M. Hirn verified this with surprise. He estimated at 35° the sudden variation of temperature. For best observation one should come very near the bar and seize the iron about 0·01 m. from the end struck (a position requiring some faith in the address of the workman!). M. Hirn thinks the phenomenon quite subjective, *i.e.*, one of sensation. In certain conditions, sonorous vibrations affecting the sensitive nerves, may cause at the periphery of the body a sensation of heat, just as, *e.g.*, pressure or a blow on the eyes may awaken in these organs the sensation of light. This view he gives with reserve, and desires physicists to test a bar, in such circumstances, with a Melloni thermometer.—Observations on M. Bouillaud's note inserted in last week's *Comptes Rendus*, by M. du Moncel.—Discovery of two small planets at Clinton (New York), by Mr. Peters.—Second letter of Mr. Watson on the discovery of intra-Mercurial planets. M. Mouchez thought that while the American observations have rendered very probable, or almost certain, the existence of intra-Mercurial planets, they have not sensibly improved the knowledge of their orbit.—Two remarks on the general relation between pressure and temperature, determined by M. Levy, by Herr Weber.—On the manner in which is distributed, among its points of application, the weight of a hard body placed on a polished, horizontal, and elastic ground; identity of this mode of distribution for a plane and horizontal supporting base with that of an electric charge in equilibrium in a thin plate of the same form, by M. Boussinesq.—On the resolution, in whole numbers, of the equation (1) $ax^4 + by^4 = cz^2$, by M. Desboves.—On a new gyroscopic pendulum, by M. Gruey.—Revision of the flora of the Malouines (Falkland Isles), by M. Crie. At present there are about 394 species (Hooker enumerated 368). The compositæ count more individuals than all the twenty-seven other families of dicotyledons combined. The gramineæ occupy the second place. As in most arctic flora, the most numerous are the cryptogams. Algæ have nearly 100 representatives. The author adds nine new species of muscineæ to those described by Hooker.—Researches on the urea of organs, by M. Picard. During digestion, urea is formed in the muscles, the brain, and the liver; these have all more of the substance than an equal weight of blood. During fasting, urea seems to be formed only in the brain and the muscles.—Note on M. Perez' work on the buzzing of insects, by M. Jousset de Bellesme. This is the substance of a paper read to the French Association in August, and giving much the same results as those of M. Perez, communicated to the Academy in September.—On *Trichodonopsis paradoxa* (Clap), by M. Schneider.—Structure and botanical affinities of the cordaites, by M. Renault. The order of Cordaiteæ is more nearly related to the Cycadeæ than any other family of Gymnosperms, and the Cycadeæ, including Sigillarineæ, must have reached an immense development at the coal epoch.—On the atmosphere of planetary bodies and the terrestrial atmosphere in particular; remarks on Mr. Sterry-Hunt's recent paper, by M. Meunier.

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