NATURE

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"*To the solid ground*
Of Nature trusts the mind which builds for aye."—WORDSWORTH

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THURSDAY, NOVEMBER 6, 1879

ON CERTAIN ERRORS RESPECTING THE STRUCTURE OF THE HEART ATTRIBUTED TO ARISTOTLE

IN all the commentaries upon the "Historia Animalium" which I have met with, Aristotle's express and repeated statement, that the heart of man and the largest animals contains only three cavities, is noted as a remarkable error. Even Cuvier, who had a great advantage over most of the commentators in his familiarity with the subject of Aristotle's description, and whose habitual caution and moderation seem to desert him when the opportunity of panegyrising the philosopher presents itself, is betrayed into something like a sneer on this topic.

"Du reste il n'attribue à cet organe que trois cavités, erreur qui prouve au moins qu'il en avait regardé la structure."[1]

To which remark, what follows will, I think, justify the reply, that it "prouve au moins" that Cuvier had not given ordinary attention, to say nothing of the careful study which they deserve, to sundry passages in the first and the third books of the "Historia" which I proceed to lay before the reader.

For convenience of reference these passages are marked *a*, *b*, *c*, &c.[2]

Book i. 17.—(*a*) "The heart has three cavities, it lies above the lung on the division of the windpipe, and has a fatty and thick membrane where it is united with the great vein and the aorta. It lies upon the aorta, with its point down the chest, in all animals that have a chest. In all, alike in those that have a chest and in those that have none, the foremost part of it is the apex. This is often overlooked through the turning upside down of the dissection. The rounded end of the heart is uppermost, the pointed end of it is largely fleshy and thick, and in its cavities there are tendons. In other animals which have a chest the heart lies in the middle of the chest; in men, more to the left side, between the nipples, a little inclined to the left nipple in the upper part of the chest. The heart is not large, and its general form is not elongated but rounded, except that the apex is produced into a point.

(*b*) "It has, as already stated, three cavities, the largest of them is on the right, the smallest on the left, the middle-sized one in the middle; they have all, also the two small ones, passages (τετρημένας) towards the lung, very evidently as respects one of the cavities. In the region of the union [with the great vein and the aorta] the largest cavity is connected with the largest vein (near which is the mesentery); the middle cavity, with the aorta.

(*c*) "Canals (πόροι) from the heart pass to the lung and divide in the same fashion as the windpipe does, closely accompanying those from the windpipe through the whole lung. The canals from the heart are uppermost.

(*d*) "No canal is common [to the branches of the windpipe and those of the vein] (οὐδεὶς δ'ἐστὶ κοινὸς πόρος) but through those parts of them which are in contact (τὴν σύναψιν) the air passes in and they [the πόροι] carry it to the heart.

(*e*) "One of the canals leads to the right cavity, the other to the left.

(*f*) "Of all the viscera, the heart alone contains blood [in itself]. The lung contains blood, not in itself but in the veins, the heart in itself; for in each of the cavities there is blood; the thinnest is in the middle cavity."

(Book iii. 3).—(*g*) "Two veins lie in the thorax alongside the spine, on its inner face; the larger more forwards, the smaller behind; the larger more to the right, the smaller, which some call *aorta* (on account of the tendinous part of it seen in dead bodies), to the left. These take their origin from the heart; they pass entire, preserving the nature of veins, through the other viscera that they reach; while the heart is rather a part of them, and more especially of the anterior and larger one, which is continued into veins above and below, while between these is the heart.

(*h*) "All hearts contain cavities, but in those of very small animals the largest (cavity) is hardly visible, those of middling size have another, and the biggest all three.

(*i*) "The point of the heart is directed forwards as was mentioned at first; the largest cavity to the right and upper side of it, the smallest to the left, and the middle sized one between these; both of these are much smaller than the largest.

(*k*) "They are all connected by passages (συντέτρηνται) with the lung, but on account of the smallness of the canals this is obscure except in one.

[1] "Histoire des Sciences Naturelles," i. p. 152.

[2] The text I have followed is that given by Aubert and Wimmer, "Aristoteles Thierkunde; kritsich berichtigter Text mit deutschen Uebersetzung;" but I have tried here and there to bring the English version rather closer to the original than the German translation, excellent as it is, seems to me to be.

(*l*) "The great vein proceeds from the largest cavity which lies upwards and to the right; next through the hollow middle (διὰ τοῦ κοίλου τοῦ μέσου) it becomes vein again, this cavity being a part of the vein in which the blood stagnates.

(*m*) "The aorta [proceeds from] the middle [cavity], but not in the same way, for it is connected [with the middle cavity] by a much more narrow tube (σύριγγα).

(*n*) "The [great] vein extends through the heart, towards the aorta from the heart.

(*o*) "The great vein is membranous like skin, the aorta narrower than it and very tendinous, and as it extends towards the head and the lower parts it becomes narrow and altogether tendinous.

(*p*) "In the first place, a part of the great vein extends upwards from the heart towards the lung and the attachment of the aorta, the vein being large and undivided. It divides into two parts, the one to the lung, the other to the spine and the lowest vertebra of the neck.

(*q*) "The vein which extends to the lung first divides into two parts for the two halves of it and then extends alongside each tube (σύριγγα) and each passage (τρῆμα), the larger beside the larger and the smaller beside the smaller, so that no part [of the lung] can be found from which a passage (τρῆμα) and a vein are absent. The terminations are invisible on account of their minuteness, but the whole lung appears full of blood. The canals from the vein lie above the tubes given off from the windpipe."

The key to the whole of the foregoing description of the heart lies in the passages (*g*) and (*l*). They prove that Aristotle, like Galen, five hundred years afterwards, and like the great majority of the old Greek anatomists, did not reckon what we call the right auricle as a constituent of the heart at all, but as a hollow part or dilatation of the "great vein." Aristotle is careful to state that his observations were conducted on suffocated animals; and if any one will lay open the thorax of a dog or a rabbit, which has been killed with chloroform, in such a manner as to avoid wounding any important vessel, he will at once see why Aristotle adopted this view.

For, the vena cava inferior (*b*), the right auricle (*R.a*) and the vena cava superior and innominate vein (*V.I.*) distended with blood, seem to form one continuous column, to which the heart is attached as a sort of appendage (*g*). This column is, as Aristotle says, vein above (*a*) and vein below (*b*), the upper and the lower divisions being connected διὰ τοῦ κοίλου τοῦ μέσου—or by means of the intervening cavity or chamber (*R.a.*)—which is the right auricle.

But when, from the four cavities of the heart recognised by us moderns, one is excluded, there remain three—which is just what Aristotle says. The solution of the difficulty is, in fact, as absurdly simple as that presented by the egg of Columbus; and any error there may be, is not to be put down to Aristotle, but to that inability to comprehend that the same facts may be accurately described in different ways, which is the special characteristic of the commentatorial mind. That the three cavities mentioned by Aristotle are just those which remain if the right auricle is omitted, is plain enough from what is said in (*b*), (*c*), (*e*), (*i*), and (*l*). For, in a suffocated animal, the "right cavity" which is directly connected with the great vein and is obviously the right ventricle, being distended with blood, will look much larger than the middle cavity, which, since it gives rise to the aorta, can only be the left ventricle. And this, again, will appear larger than the thin and collapsed left auricle, which must be Aristotle's left cavity, inasmuch as this cavity is said to be connected by πόροι with the lung. The reason why Aristotle considered the left auricle to be a part of the heart, while he merged the right auricle in the great vein, is, obviously, the small relative size of the venous trunks and their sharper demarcation from the auricle. Galen, however, perhaps more consistently, regarded the left auricle also as a mere part of the "arteria venosa." The canal which leads from the right cavity of the heart to the lung is, without doubt, the pulmonary artery. But it may be said that, in this case, Aristotle contradicts himself, inasmuch as in (*p*) and (*q*) a vessel which is obviously the pulmonary artery, is described as a branch of the great vein. However, this difficulty also disappears, if we reflect that, in Aristotle's way of looking at the matter, the line of demarcation between the great vein and the heart coincides with the right auriculo-ventricular aperture; and that, inasmuch as the conical prolongation of the right ventricle which leads to the pulmonary artery (Fig. 1, *R.v'*), lies close in front of the auricle, its base may very easily (as the figure shows) be regarded as part of the general opening of the great vein into the right ventricle. In fact

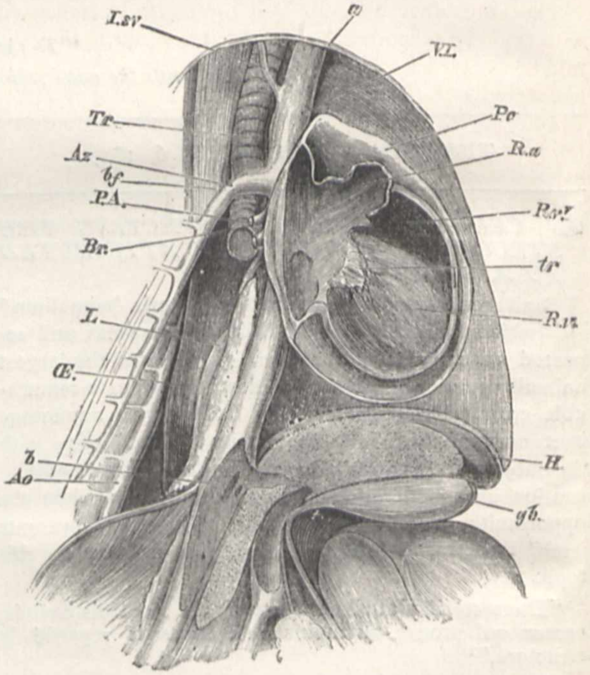


FIG. 1.—A dog having been killed by chloroform, enough of the right wall of the thorax was removed, without any notable bleeding, to expose the thoracic viscera. A carefully measured outline sketch of the parts *in situ* was then made, and on dissection, twenty-four hours afterwards, the necessary anatomical details were added. The woodcut is a faithfully reduced copy of the drawing thus constructed; and it represents the relations of the heart and great vessels as Aristotle saw them in a suffocated animal.

All but the inner lobe of the right lung has been removed; as well as the right half of the pericardium and the right walls of the right auricle and ventricle. It must be remembered that the thin transparent pericardial membrane appears nothing like so distinct in nature.

a.b., Aristotle's "great vein"; *V.I.*, right vena innominata and vena cava superior; *b*, the inferior vena cava; *R.a*, the "hollow middle" part of the great vein or the right auricle; *R.v'*, the prolongation of the cavity of the right ventricle *R.v* towards the pulmonary artery; *tr*, one of the tricuspid valves; *Pc*, the pericardium; *I.sv*, superior intercortal vein; *Az*, vena azygos; *P.A.*, right pulmonary artery; *Br*, right bronchus; *L*, posterior lobe of the right lung; *Œ*, œsophagus; *Ao*, descending aorta; *H*, liver, in section, with hepatic vein, vena portæ, and gall-bladder, *gb*, separated by the diaphragm, also seen in section, from the thoracic cavity.

it is clear that Aristotle, having failed to notice the valves of the heart, did not distinguish the part of the right ventricle from which the pulmonary artery arises (*R.v'*) from the proper trunk of the artery on the one hand, and from the right auricle (*R.a*) on the other. Thus the root, as we may call it, of the pulmonary artery and the right auricle, taken together, are spoken of as the "part of the great vein which extends upwards;" and, as the vena azygos (*Az*) was one branch of this, so the "vein to the lung" was another branch of it. But the latter branch, being given off close to the connection of the great vein with the ventricle, was also counted as one of the two πόροι by which the "heart" (that is to say the right ventricle, the left ventricle, and the left auricle of our nomenclature) communicates with the lung.

The only other difficulty that I observe, is connected with (*k*). If Aristotle intended by this to affirm that the middle cavity (left ventricle), like the other two, is directly connected with the lung by a πόρος, he would be in error. But he has excluded this interpretation of his words by (*e*), in which the number and relations of the canals, the existence of which he admits, are distinctly defined. I can only imagine then, that so far as this passage applies to the left ventricle, it merely refers to the indirect communication of that cavity with the vessels of the lungs, through the left auricle.

On this evidence I submit that there is no escape from the conclusion that, instead of having committed a gross blunder, Aristotle has given a description of the heart which so far as it goes, is remarkably accurate. He is in error only in regard to the differences which he imagines to exist between large and small hearts (*h*).

Cuvier (who has been followed by other commentators) ascribes another error to Aristotle :—

"Aristote suppose que la trachée-artère se prolonge jusqu'au cœur, et semble croire, en conséquence, que l'air y pénètre (*l. c.* p. 152)."

Upon what foundation Cuvier rested the first of these two assertions, I am at a loss to divine. As a matter of fact, it will appear from the following excerpts that Aristotle gives an account of the structure of the lungs which is almost as good as that of the heart, and that it contains nothing about any prolongation of the windpipe to the heart.

"Within the neck lie what is called the œsophagus (so named on account of its length and its narrowness) and the windpipe (ἀρτηρία). The position of the windpipe in all animals that have one, is in front of the œsophagus. All animals which possess a lung have a windpipe. The windpipe is of a cartilaginous nature and is exsanguine, but is surrounded by many little veins . . . .

"It goes downwards towards the middle of the lung and then divides for each of the halves of the lung. In all animals that possess one, the lung is divided into two parts; but, in those which bring forth their young alive, the separation is not equally well marked, least of all in man.

"In oviparous animals, such as birds, and in quadrupeds which are oviparous, the one half of the lung is widely separated from the other; so that it appears as if they had two lungs. And from being single the windpipe becomes [divided into] two, which extend to each half of the lung. It is fastened to the great vein and to what is called the aorta. When the windpipe is blown up the air passes into the hollow parts of the lung. In these, are cartilaginous tubes (διαφύσεις) which unite at an angle; from the tubes passages (τρήματα) traverse the whole of the lung; they are continually given off, the smaller from the larger." (Book i., 16.)

That Aristotle speaks of the lung as a single organ divided into two halves and says that the division is least marked in man, is puzzling at first, but becomes intelligible if we reflect upon the close union of the bronchi, the pulmonary vessels and the mediastinal walls of the pleuræ in mammals;[1] and it is quite true that the lungs are much more obviously distinct from one another in birds.

Aubert and Wimmer translate the last paragraph of the passage just cited as follows :—

"Diese haben aber knorpelige Scheidewände, welche unter spitzen Winkeln zusammentreten, und aus ihnen führen Oeffnungen durch die ganze Lunge, indem sie sich in immer kleineren verzweigen."

But I cannot think that by διαφύσεις and τρήματα, in this passage, Aristotle meant either "partitions" or openings in the ordinary sense of the latter word. For, in Book iii., Cap. 3, in describing the distribution of the "vein which goes to the lung" (the pulmonary artery), he says that it

"Extends alongside each tube (σύριγγα) and each passage (τρῆμα), the larger beside the larger, and the smaller beside the smaller; so that no part [of the lung] can be found from which a passage (τρῆμα) and a vein are absent."

Moreover, in Book i., 17, he says—

"Canals (πόροι) from the heart pass to the lung and divide in the same fashion as the windpipe does, closely accompanying those from the windpipe through the whole lung."

And again in Book i., 17.—

"It (the lung) is entirely spongy, and alongside of each tube (σύριγγα) run canals (πόροι) from the great vein."

On comparing the last three statements with the facts of the case, it is plain that by σύριγγες, or tubes, Aristotle means the bronchi and so many of their larger divisions as obviously contain cartilages; and that by διαφύσεις χονδρώδεις he denotes the same things; and, if this be so, then the τρήματα must be the smaller bronchial canals, in which the cartilages disappear.

This view of the structure of the lung is perfectly correct so far as it extends; and, bearing it in mind, we shall be in a position to understand what Aristotle thought about the passage of air from the lungs into the heart. In every part of the lung, he says, in effect, there is an air tube which is derived from the trachea, and other tubes which are derived from the πόροι which lead from the lung to the heart, *suprà* (*c*). Their applied walls constitute the thin "synapses" (τὴν σύναψιν) through which the air passes out of the air tubes into the πόροι, or blood vessels, by transudation or diffusion; for there is no community between the cavities of the air tubes and cavities of the canals; that is to say, no opening from one into the other, *suprà* (*d*).

On the words "κοινὸς πόρος" Aubert and Wimmer remark (*l.c.* p. 239), "Da A. die Ansicht hat die Lungenluft würde dem Herzen zugeführt, so postulirt er statt vieler kleiner Verbindungen einen grossen Verbindungsgang zwischen Lunge und Herz."

But does Aristotle make this assumption? The only evidence so far as I know in favour of the affirmative answer to this question is the following passage :—

[1] In modern works on Veterinary Anatomy the lungs are sometime described as two lobes of a single organ.

"*Συνήρτεται δὲ καὶ ἡ καρδία τῇ ἀρτηρίᾳ πιμελώδεσι καὶ χονδρώδεσι καὶ ἰνώδεσι δεσμοῖς· ᾗ δέ συνήρτεται, κοῖλόν ἐστιν. φυσωμένης δὲ τῆς ἀρτηρίας ἐν ἐνίοις μὲν οὐ κατάδηλον ποιεῖ, ἐν δὲ τοῖς μείζοσι τῶν ζῴων δῆλον ὅτι εἰσέρχεται τὸ πνεῦμα εἰς αὐτήν*" (i. cap. 16).

"The heart and the windpipe are connected by fatty and cartilaginous and fibrous bands; where they are connected it is hollow. Blowing into the windpipe does not show clearly in some animals, but in the larger animals it is clear that the air goes into it."

Aubert and Wimmer give a somewhat different rendering of this passage:—

"Auch das Herz hängt mit der Luftröhre durch fettreiche, knorpelige und faserige Bänder zusammen; und da, wo sie zusammenhängen, ist eine Höhlung. Beim Aufblasen der Lunge wird es bei manchen Thieren nicht wahrnehmbar, bei den grösseren aber ist es offenbar, dass die Luft in das Herz gelangt."

The sense here turns upon the signification which is to be ascribed to *εἰς αὐτήν*. But if these words refer to the heart, then Aristotle has distinctly pointed out the road which the air, in his opinion, takes, namely, through the "synapses"; and there is no reason that I can discover to believe that he "postulated" any other and more direct communication.

With respect to the meaning of *κοῖλόν ἐστιν*, Aubert and Wimmer observe:—

"Dies scheint wohl die kurze Lungenvene zu sein. Schneider bezieht dies auf die Vorkammern, allein diese werden unten als Höhlen des Herzens beschrieben."

I am disposed to think, on the contrary, that the words refer simply to the cavity of the pericardium. For a part of this cavity (*sinus transversus pericardii*) lies between the aorta, on the one hand, and the pulmonary vessels with the bifurcation of the trachea, on the other hand, and is much more conspicuous in some animals than in man. It is strictly correct, therefore, in Aristotle's words, to say that where the heart and the windpipe are connected "it is hollow." If he had meant to speak of one of the pulmonary veins, or of any of the cavities of the heart, he would have used the terms *πόροι* or *κοιλίας* which he always employs for these parts.

According to Aristotle, then, the air taken into the lungs passes from the final ramifications of the bronchial tubes into the corresponding branches of the pulmonary blood vessels, not through openings, but by transudation, or, as we should nowadays say, diffusion, through the thin partitions formed by the applied coats of the two sets of canals. But the "pneuma" which thus reached the interior of the blood vessels was not, in Aristotle's opinion, exactly the same thing as the air. It was "*ἀήρ πολὺς ῥέων καὶ ἀθρόος*" ("De Mundo," iv., 9)—subtilized and condensed air; and it is hard to make out whether Aristotle considered it to possess the physical properties of a gas or those of a liquid. As he affirms that all the cavities of the heart contain blood (*f*), it is clear that he did not hold the erroneous view propounded in the next generation by Erasistratus. On the other hand, the fact that he supposes that the spermatic arteries do not contain blood but only an *αἱματώδης ὑγρόν* ("Hist. Animalium," iii., 1), shows that his notions respecting the contents of the arteries were vague. Nor does he seem to have known that the pulse is characteristic only of the arteries; and as he thought that the arteries end in solid fibrous bands, he naturally could not have entertained the faintest conception of the true motion of the blood. But without attempting to read into Aristotle modern conceptions which never entered his mind, it is only just to observe that his view of what becomes of the air taken into the lungs is by no means worthy of contempt as a gross error. On the contrary, here, as in the case of his anatomy, what Aristotle asserts is true as far as it goes. Something does actually pass from the air contained in the lungs through the coats of the vessels into the blood, and thence to the heart; to wit, oxygen. And I think that it speaks very well for ancient Greek science that the investigator of so difficult a physiological problem as that of respiration, should have arrived at a conclusion, the statement of which, after the lapse of more than two thousand years, can be accepted as a thoroughly established scientific truth.

I trust that the case in favour of removing the statements about the heart, from the list of the "errors of Aristotle" is now clear; and that the evidence proves, on the contrary, that they justify us in forming a very favourable estimate of the oldest anatomical investigations among the Greeks of which any sufficient record remains.

But is Aristotle to be credited with the merit of having ascertained so much of the truth? This question will not appear superfluous to those who are acquainted with the extraordinary history of Aristotle's works, or who adopt the conclusion of Aubert and Wimmer, that, of the ten books of the "Historia Animalium" which have come down to us, three are largely or entirely spurious and that the others contain many interpolations by later writers.

It so happens, however, that, apart from other reasons, there are satisfactory internal grounds for ascribing the account of the heart to a writer of the time at which Aristotle lived. For, within thirty years of his death, the anatomists of the Alexandrian school had thoroughly investigated the structure and the functions of the valves of the heart. During this time, the manuscripts of Aristotle were in the possession of Theophrastus; and no interpolator of later date would have shown that he was ignorant of the nature and significance of these important structures, by the brief and obscure allusion—"in its cavities there are tendons (*a*)." On the other hand, Polybus, whose account of the vascular system is quoted in the "Historia Animalium" was an elder contemporary of Aristotle. Hence, if any part of the work faithfully represents that which Aristotle taught, we may safely conclude that the description of the heart does so. Having granted this much, however, it is another question, whether Aristotle is to be regarded as the first discoverer of the facts which he has so well stated, or whether he, like other men, was the intellectual child of his time and simply carried on a step or two the work which had been commenced by others.

On the subject of Aristotle's significance as an original worker in biology extraordinarily divergent views have been put forward. If we are to adopt Cuvier's estimate, Aristotle was simply a miracle:—

"Avant Aristote la philosophie, entièrement spéculative, se perdait dans les abstractions dépourvues de fondement; la science n'existait pas. Il semble qu'elle soit sortie toute faite du cerveau d'Aristote comme Minerve, toute armée, du cerveau de Jupiter. Seul, en effet, sans antécédents, sans rien emprunter aux siècles qui l'avaient précédé, puisqu'ils n'avaient rien produit de solide, le disciple de Platon découvrit et démontra plus de vérités, executa plus de travaux scientifiques en un vie de soixante-deux ans, qu'après lui vingt siècles n'en ont pu faire,"[1] &c., &c.

"Aristote est le premier qui ait introduit la méthode de l'induction, de la comparaison des observations pour en faire sortir des idées générales, et celle de l'expérience pour multiplier les faits dont ces idées générales peuvent être déduites."—ii. p. 515.

The late Mr. G. H. Lewes,[2] on the contrary, tells us "on a superficial examination, therefore, he [Aristotle] will seem to have given tolerable descriptions; especially if approached with that disposition to discover marvels which unconsciously determines us in our study of eminent writers. But a more unbiased and impartial criticism will disclose that he has given no single anatomical description of the least value. All that he knew may have been known and probably was known, without dissection. . . . . I do not assert that he never opened an animal; on the contrary, it seems highly probable that he had opened many . . . . . . He never followed the course of a vessel or a nerve; never laid bare the origin and insertion of a muscle; never discriminated the component parts of organs; never made clear to himself the connection of organs into systems."—(pp. 156-7.)

In the face of the description of the heart and lungs, just quoted, I think we may venture to say that no one who has acquired even an elementary practical acquaintance with anatomy, and knows of his own knowledge that which Aristotle describes, will agree with the opinion expressed by Mr. Lewes; and those who turn to the accounts of the structure of the rock lobster and that of the lobster, or to that of the Cephalopods and other Mollusks, in the fourth book of the "Historia Animalium" will probably feel inclined to object to it still more strongly.

On the other hand, Cuvier's exaggerated panegyric will as little bear the test of cool discussion. In Greece, the century before Aristotle's birth was a period of great intellectual activity, in the field of physical science no less than elsewhere. The method of induction has never been used to better effect than by Hippocrates; and the labours of such men as Alkmeon, Demokritus, and Polybus among Aristotle's predecessors, Diokles, and Praxagoras, among his contemporaries, laid a solid foundation for the scientific study of anatomy and development, independently of his labours. Aristotle himself informs us that the dissection of animals was commonly practised; that the aorta had been distinguished from the great vein; and that the connection of both with the heart had been observed by his predecessors. What they thought about the structure of the heart itself, or that of the lungs, he does not tell us, and we have no means of knowing. So far from arrogantly suggesting that he owed nothing to his predecessors, Aristotle is careful to refer to their observations and to explain why, in his judgment, they fell into the errors which he corrects.

Aristotle's knowledge, in fact, appears to have stood in the same relation to that of such men as Polybus and Diogenes of Apollonia, as that of Herophilus and Erasistratus did to his own, so far as the heart is concerned. He carried science a step beyond the point at which he found it; a meritorious, but not a miraculous, achievement. What he did required the possession of very good powers of observation; if they had been powers of the highest class he could hardly have left such conspicuous objects as the valves of the heart to be discovered by his successors.

And this leads me to make a final remark upon a singular feature of the "Historia Animalium." As a whole, it is a most notable production, full of accurate information and of extremely acute generalisations of the observations accumulated by naturalists up to that time. And yet, every here and there, one stumbles upon assertions respecting matters which lie within the scope of the commonest inspection, which are not so much to be called errors as stupidities. What is to be made of the statement that the sutures of women's skulls are different from those of men; that men and sundry male animals have more teeth than their respective females; that the back of the skull is empty, and so on? It is simply incredible to me that the Aristotle who wrote the account of the heart, also committed himself to absurdities which can be excused by no theoretical prepossession and which are contradicted by the plainest observation.

What, after all, were the original manuscripts of the "Historia Animalium"? If they were notes of Aristotle's lectures taken by some of his students, any lecturer who has chanced to look through such notes, would find the interspersion of a foundation of general and sometimes minute accuracy, with patches of transcendent blundering, perfectly intelligible. Some competent Greek scholar may perhaps think it worth while to tell us what may be said for or against the hypothesis thus hinted. One obvious difficulty in the way of adopting it is the fact that, in other works, Aristotle refers to the "Historia Animalium" as if it had already been made public by himself.

T. H. HUXLEY

[1] "Histoire des Sciences Naturelles."—t. i. p. 130.
[2] "Aristotle, a Chapter from the History of Science."

ON THE NECESSITY FOR A NEW DEPARTURE IN SPECTRUM ANALYSIS

IT is now about a year since I gave an account of the results to which the final discussion of a complete set of photographs of the spectra of the metallic elements compared with the spectrum of the sun had led me.

The comparison was limited necessarily to the blue and violet portions of the spectrum, as photography was employed, and the methods since worked out by Capt. Abney for photographing the other regions were not then available. Of set purpose I limited it still more, as I wished to find the *dernier mot* in the present state of science regarding the coincidence of metallic with Fraunhofer's lines; and for this it was imperative to work on a large scale over a small region rather than on a small scale over a large one.

In point of fact, the work was limited to about the $\frac{1}{100}$th part of the spectrum, and this small part was mapped on a large scale. A complete map of the spectrum on the scale adopted would be about half a furlong long. The work took time: including interruptions of one kind and another, some four years were expended on it.

I have elsewhere discussed at some length the conclusion which stared us in the face when all the work was brought to focus, but it is important that I should here dwell upon it for a moment, especially as it is now possible, perhaps, to state it with more terseness and clearness than one could at first, when the new conception thus forced upon us and its consequences were less familiar to one's mind.

Simply, it amounted to this. The new work had made us acquainted with the fact that there were coincidences in the lines of metallic spectra of two perfectly distinct kinds.

The lines of one kind we could explain, on the hypothesis that the elements are truly elementary, by supposing that in the case, let us say, of coincident lines in the spectrum of iron and cobalt, the common line was due to an impurity either of iron in the cobalt or of cobalt in the iron. Most spectroscopic workers were of the true faith in this matter; they accepted the dicta of the chemist, and not only was the work which had shown how the phenomena observed *might be* thus explained received with favour, but no one, so far as I know, inquired whether there was any other "might be" in the matter. It is more than probable, however, that the future will have much to say on this very point; but with this set of coincidences I am not dealing in this paper.

So much for the one set of coincidences.

The other set was as different as possible. In this category there was, on the impurity hypothesis, no possible explanation forthcoming without changing ground. In fact, the separation of the coincidences into two classes was brought about by this very circumstance, since all the coincidences which, in accordance with a general law established for a constant temperature some years before, could be attributed to impurity had, as a matter of fact, been eliminated from the maps at a prior stage of the investigation. Further, be it noted that all the photographs represented the work of similar temperatures, for they were all taken with electric arcs, for the production of which the same number of Grove's cells was used in all cases.

Since therefore these lines which were common to two or more spectra, could not be traced to impurities, what was their probable origin? Their number was so great that to attribute them to physical coincidences, and to rest and be thankful accordingly, would have been to take the very pith and marrow out of the science of spectrum analysis, which we have heard so often is based absolutely upon different substances giving us spectra with special lines for each. The matter then was worthy of serious investigation.

Using the analogy presented by the spectroscopic behaviour of known compounds when simplified by heat, a simple explanation of these common lines lay on the surface. This explanation is as follows:—

The temperature of the sun and the electric arc is high enough to dissociate some of the so-called chemical elements, and give us a glimpse of the spectra of their bases, just as in the case of the various salts of calcium there is a temperature which just allows us to get a glimpse of a line indicating the metal calcium common to them all.

Hence it was allowable to term the coincident lines of the second order "basic lines," since they might point to the existence of a base common to the substances in the spectra of which they appeared. Davy, before he discovered potassium, used, as I have since found, the word "basic" to express the same idea.

I propose in the present paper to refer to some of the facts collected along one line of work to which my subsequent studies of these lines has led me, with a view to show that their true basic nature can now no longer be open to doubt.

Naturally the first thing to do was to see if these basic lines varied in their behaviour from other lines of spectra taken at random. Supposing them to represent mere chance coincidences—"physical coincidences," as they have been called, or again, lines so near together that our means cannot separate them—there is no reason why they should vary together when the temperature is changed; while, if they be truly basic, they *must* vary with temperature. Further, they must vary in such a way that other conditions being equal, they shall become stronger when the temperature is increased, and become fainter when the temperature is reduced.

Now what was the best mode of attacking this problem? I was unable to see a more expeditious one than that presented to us by the sun. The following consideration will show how we might hope for help in this quarter.

We are accustomed to say that the sun is surrounded by an enormous atmosphere, and that this atmosphere has in it the vapours of metals, such as iron, magnesium, &c., with which metals we are familiar on this planet. This statement has been based on the near agreement presented by the places of the lines in the spectrum of the substances as studied in our laboratories and the Fraunhofer lines themselves. The matching of these spectra is nothing like so perfect, and the conclusion drawn, therefore, is nothing like so firmly based, as is generally imagined; but this point need not occupy our attention at present; what it is important for us to bear in mind is this: whatever be the chemical nature of this atmosphere, it will certainly be hotter at bottom—that is, nearer the photosphere—than higher up. Hence, if temperature plays any part in moulding the conditions by which changes in the resulting spectrum are brought about, the spectrum of the atmosphere close to the photosphere will be different from that of any higher region, and therefore from the general spectrum of the sun, which practically gives us the summation of all the absorptions of all the regions from the top of the atmosphere to the bottom.

Now as a matter of fact we have the opportunity, when we observe the spectrum of a sun-spot or a prominence, of determining the spectrum of an isolated mass of vapours in the hottest region open to our inquiries, and seeing whether it is like or unlike the general spectrum of the sun. What then are the facts?

It is as unlike as possible: the intensities of the lines are inverted to a wonderful extent. More than this there is a constant difference between the spectra of sun-spots and the spectra of metallic prominences, though we see these phenomena generally at about the same *niveau* in the sun's atmosphere. This may arise from the fact that in the case of the spots we deal generally with a greater thickness of the vapours.

To get the best idea of this inversion I have prepared maps of the spectra of the chief chemical substances showing the behaviour of the various lines under the various conditions. The result is very striking; indeed it is striking to quite an unexpected degree. The whole character of the spectrum of iron, for instance, is changed when we pass from the iron lines seen among the Fraunhofer lines to those seen among the spot-and storm-lines; a complex spectrum is turned into a simple one, the feeble lines are exalted, the stronger ones suppressed almost altogether.

Since then the spectra of spots and prominences are confessedly the spectra of the hottest region of the sun available to our inquiries, we can test the nature of the basic lines by seeing how they behave when we pass from the general solar to these special solar spectra.

With special reference to this point I have brought together the various observations which have been recorded of the lines visible in solar disturbances at the sun's limb, and those observed to be widened, brightened, or otherwise modified in the spectra of solar spots.

The finest series of observations of this kind that we possess is that collected by Prof. Young near the time of the last maximum of sun-spots, during his stay at Sherman, at a height of 8,000 feet. The result which stares us in the face when we examine the work done by Young is most striking; but although his observations of the chromospheric lines extend over the whole visible spectrum, the list of lines in the solar spots is limited to the less refrangible region; we must therefore limit the discussion to this region.

As a basis for the discussion, I have used the lines given in Thalén's admirable tables, comparing them with those shown in Ångström's map, and indicating the intensities of the lines which are given in the tables, and which particular line occurs in the map only. A glance then shows which line is seen in spots and prominences, and how it is affected. In short we have in one view, for each metallic substance, exactly what happens to the lines of that substance—which lines are not touched; those which are visibly affected both in spots and storms, or those recorded in one table and not in the other.

Taking all the lines included in the discussion, the following statistics will show how they are distributed:—

Total number of lines in Thalén's list and map included in the discussion	345
Number of lines affected in spots	108
Number of lines bright in storms	122
Number of lines common to spots and storms	68
Number of lines seen in neither spots nor storms	183

So much for the list of lines as a whole. It is also necessary to show the number of lines assigned to each metal, and those among them which occur in both spots and storms, or only in one or the other.

Metal.	Number of Lines.	Number of lines common to spots and storms.	Number of lines due to		Unaffected.
			Spots.	Storms.	
Sodium ...	8	4	6	6	0
Magnesium	4	3	4	3	0
Barium ...	23	1	3	7	14
Calcium ...	25	7	15	10	7
Strontium ...	18	0	0	0	18
Nickel... ...	12	1	3	2	8
Cobalt... ...	19	3	3	3	16
Manganese ...	16	2	3	6	9
Cadmium ...	15	0	0	0	15
Chromium ...	14	3	3	5	9
Titanium ...	87	11	18	18	62
Iron... ...	104	33	50	62	25
	345	68	108	122	183

It will be seen that the ratio between the affected and unaffected lines is very variable. What strikes one, indeed, is the wonderful irregularity in the behaviour of the various lines; there is no relation, for instance, between the widening of the lines in the spots and their appearances in the prominences.

It may here be asked, "But what has this to do with basic lines?" I answer, it would have nothing to do with basic lines if Thalén had not observed them; but in his observations, which are the *ne plus ultra* of spectroscopic accuracy, he came across them abundantly. The basic lines therefore have the great advantage of not being new.

Among the 345 *lines given by Thalén are* 18 *with identical readings in two spectra.* They are, therefore, the exact equivalents of those lines which I have found to be basic in work on another part of the spectrum.

Now, for the reasons above given, if my explanation of their basic character be the correct one, then we should expect a considerable development of these lines in the spectrum of the hottest regions of the sun, which spots and storms enable us to study apart from the absorption going on at higher levels.

It is not too much to say that the result of this inquiry settles this question in the most conclusive way. What does come out in the strongest manner is the following very remarkable fact.

The only constant thing in the tables employed in the inquiry is, that *these basic lines are always widened in the spots.* However badly the brighter lines of a chemical substance, taken as a whole, may be represented amongst the spot lines, as the basic lines, among these which are often of the second or third order of intensity and sometimes even of the fourth, are never absent. The same fact holds almost equally true with regard to the storms.

The following comparison of Thalén's basic lines with those seen by Young in solar spots and storms shows this result:—

Thalén.					Young.		
Wave-length.	Common to		Intensity.		Spots.	Storms.	
					Widening.	Frequency.	Brightness.
5207·6	Fe	Cr	3	1	4	10	6
5203·7	Fe	Cr	3	1	4	10	6
5340·2	Fe	Mn	2	3	2	1	2
6064·5	Fe	Ti	2	2	3	5	2
5661·5	Fe	Ti	3	1	4	15	2
5403·1	Fe	Ti	2	3	4	5	3
5396·1	Fe	Ti	2	2	7	4	2
5352·4	Fe	Co	4	3	2	4	2
5265·8	Fe	Co	2	3	2	10	4
5168·3	Fe	Ni	3	5	4	40	30
5166·7	Fe	Mg	2	1	2	30	20
5681·4	Fe	Na	3	3	3	2	1
6121·2	Co	Ca	1	3	4	5	3
5601·7	Ca	Fe	4	1	2		
5597·2	Ca	Fe	3	1	2		
5856·5	Ca	Ni	3	4	2		
5425·0	Ba	Ti	3	3	4		
6449·0	Ca	Ba	2	3	2		

So far as my own knowledge of these matters goes, I can imagine no severer test to apply to the hypothesis that the basic lines in the above table are produced by the dissociation of the metals to which the lines are common—in this case chiefly the metals of the iron group—in the hottest region of the sun, and to my mind the proof is conclusive that at that temperature we have a mixed mass of vapours in which the base is more predominant than the so-called chemical elements to which that base is common.

But although I hold that this is the most conclusive test to apply, it is not the only one which the sun affords us.

We have every reason to believe that there is a considerable difference in the temperature of the spot- and storm-stratum when it is absolutely quiescent and cut off from all visible action from below, and again when it is riddled with convection currents of the most tremendous character—in other words that its temperature at the sun-spot maxima and minima is not the same. Hence we may imagine that the difference of temperature will affect the basic lines especially, and that they will be stronger at one period of the sun-spot curve than at another.

I limit myself for the present to the statement that this comparison has also been made to a certain extent, and that the result of it is entirely in harmony with what has gone before, so far as the observations go, but more spots must be observed before a complete discussion is possible. This, however, is certain, that basic lines widened at Sherman in 1872 were not observed widened at Greenwich in 1877, or at Kensington in the spots which appeared last month.

I for my part, then, am perforce driven by the stern logic of facts to the conclusion that these "basic lines" are not accidental; are not "physical coincidences;" and do not owe their origin to impurities; but that their appearance in two or more spectra is dependent upon high temperature merely.

The original statement, then, that the spectrum of each element consists only of lines special to that element, is found to be insufficient when the highest temperatures and the greatest dispersions are employed, and a "higher law" has to be introduced to bring the statements of the text-books into harmony with the facts.

The dissociation of the elements of the iron group at the highest temperatures we can command and in the sun, is a cause by which this fact can be explained, if we accept the law of continuity, and reason on well based analogies.

This, of course, constitutes a new departure in spectrum analysis, whatever its bearing may be found to be upon Chemical Philosophy, when that subject is again studied as it once was.

To those who follow the line of reasoning on such a subject which the spectroscope provides us with, and even to those who admit the cogency of the conclusions, it will be astonishing that such a result has been arrived at in such an indirect way; there are, however, many minds so constituted that they will prefer to endow matter with any number of undreamt of qualities before they will accept such a solution.

But for all that, when the facts are well considered by competent authorities, it will, I think, be granted that an inorganic evolution is already glimpsed, in the study of which we shall not be baffled by any "breaks in strata."

J. NORMAN LOCKYER

MIND IN THE LOWER ANIMALS

Mind in the Lower Animals in Health and Disease. By W. Lauder Lindsay, M.D., F.R.S.E., F.L.S., &c. (London: C. Kegan Paul and Co., 1879.)

DR. LAUDER LINDSAY has long been known as a contributor to periodical literature in the province of comparative psychology. The work which he now publishes with the above title clearly represents a great amount of labour. It is in two large octavo volumes which together present somewhat over 1,000 pages, and contain references to the writings of about 200 authors. It is furnished with an excellent index and a bibliography. The latter, we are told, is "confined to works consulted by the author," and "almost exclusively to those published in Britain and in the English language." The work is also furnished with a long "enumeration of the animals whose character and habits form the basis of the author's generalisations." The list includes 908 species belonging to 516 genera, both the popular and the scientific names being in every case supplied.

In so extensive a work by so well-known a man there is, as we should expect, a great deal that is both of interest and value. Particularly in this connection may be pointed out his compilation and digestion of facts regarding the psychology of savages as contrasted with that of animals, and also many of his observations on the insanity of animals as compared with the insanity of man. His chapters on "General Adaptiveness and "The Use of Instruments" also deserve, on the whole, to be commended.

But while we welcome a book—and especially a popular book—the leading object of which is to prove the kinship of animal intelligence to human, it is impossible not to regret the occurrence of certain faults which the exercise of a little more judgment might have obviated. In the first place the work is painfully diffuse. Whole pages, and even chapters, might with advantage have been omitted, while there are but few chapters which might not, with equal advantage, have been considerably condensed. Those, for instance, on "Faults of Terminology," "Animal Reputation," "Responsibility of Animals," and others, appear utterly useless. Whether or not it is accurate to call the lower animals "dumb," "lower," &c., and whether or not the "reputation" of a dog suffers from the use of such terms as "dogging," "hounding," "cat and dog life," &c., and whether or not any one is so foolish as to suppose that a smuggler's dog is morally responsible for a smuggler's acts; whether or not these things are so, they are certainly not of sufficient importance to demand lengthy discussion. Again, such statements as the following are quite superfluous, at least out of a nursery-book:—

> "While the dog barks, bites, growls, howls, whines, sniffs, and snarls; the horse neighs, kicks, stamps, paws, snorts, champs, lashes its tail; the cat purrs, scratches, hisses, mews; cattle low, butt, gore, bellow; the elephant trumpets, roars, screams; the sheep and goat bleat; the ass brays, the cock crows, and the hen clucks and cackles."

This is all quite true, but it is not new; and the same remark is applicable to pages and pages of both volumes. In short, unlimited diffusiveness is the worst fault of the book. The next worst fault is that of presenting alleged facts of animal intelligence on evidence that is obviously insufficient. Thus, for example, we are told that the hermit crab "has been noticed to feed the anemone (on his shell) with his pincer-like claws;" that ants "employ language of command;" that "snails are capable of concerted action;" that fish may die of "grief from bereavement;" that dogs exhibit "modesty or decency;" that monkeys "turn keys in doors, without noise, to secure themselves against interruption, discovery, or capture;" and so on, while in none of these cases are any facts or authorities given to support the assertions. Again, in many other cases where the facts and authorities are given, they are of a kind that ought not to have any place in a treatise which aims at a scientific discussion of its subject. For instance, we are told, without any expression of doubt on the part of the author, that "Daniell shows how a mere passing fancy for—a glimpse at—some dog, on the part of a pointer bitch, so impressed her memory and imagination that she transmitted this impress in a physical form to her progeny." Again, on no better authority than that of *The Animal World*—from which, indeed, Dr. Lindsay is very fond of quoting—we are expected to believe that "certain sparrows that failed, by seizing its wings with their bills, to lift a wounded companion, so as to convey it to a position of safety, got a twig, and while the maimed bird took hold of its centre by its bill, two of its companions seized, one each of its ends, so raised the helpless sparrow from the ground, and removed it to a safer place." And, to give only one other illustration, on the authority of an American paper called the *Christian Union*, we are told this painfully pathetic story:—"A young rat had fallen into a pail of pig-food; six older ones held a consultation so earnest in its character as to lead them to ignore the presence of human on-lookers. They decided on an ingenious scheme of rescue, and successfully carried it out. Entwining their legs together, they formed a chain, hanging downwards over the edge of the pail. The foremost or downmost rat grasped the drowning, and, as it subsequently proved, drowned, young one in its fore-paws, and both rescued and rescuer were then drawn up and out. When found to be dead, the rescuers gazed at their young comrade in 'mute despair,' wiped the tears from their eyes with their fore-paws, and departed without making any attempts to resuscitate it."

Evidently these rats were not acquainted with the Royal Humane Society's directions for the restoration of the apparently drowned, and considering that the calamity occurred in a civilised country, the most striking feature of the incident appears to be the ignorance which the animals displayed in yielding to grief "without making any attempts" to produce artificial respiration.

Another fault which pervades the work is that of undue eagerness to prove that no difference in kind exists between the mind of man and the mind of the lower animals—a fault which leads the author into the opposite error of disparaging such difference as does exist. Thus the book abounds with such statements as the following:—"There are countless thousands—many whole races—(of men) that are intellectually and morally the *inferiors* of many well-trained mammals, such as the chimpanzee, orang, dog, elephant, or horse; or birds, such as the parrot, starling, magpie, jackdaw, and various crows; as well as many animals much lower in the zoological scale, and not trained by man at all, such as the ant, bee, and wasp." And this belief in the mental equality, or even superiority, of animals as compared with the lower races of man, is doubtless the explanation of the writer's tendency to attribute to rational thought actions of animals which are much more probably due to other causes. For instance: "A cat was found drowned in a pond immediately after the death of a master to whom it had been much attached. It had left the house on his illness a fortnight previously, refusing to enter it again (*Animal World*). The inference was that grief had led to deliberate self-destruction; but the verdict of accidental drowning, is, of course, equally permissible." The word "equally" here serves to illustrate our meaning.

With regard to references there is also a serious complaint to be made. It is not enough to give the name of an author without any reference to the part of his writings where his facts or opinions are stated. Thus, although Dr. Lindsay's pages are thickly strewn with the names of his authorities in brackets, his readers will but rarely have the opportunity, without an impracticable amount of trouble, of seeing exactly what these authorities themselves have to say on the topics in connection with which they are quoted.

On minor faults or errors it is needless to dwell—such as the curious notion which Dr. Lindsay seems to entertain, that the word "glutton" is derived from the synonym of the wolverine, instead of *vice versâ* (p. 92). The chief faults are undoubtedly those which have been mentioned, and they have been mentioned in order to suggest that, should there be a second edition of the book, it would be greatly improved by presenting less diffusiveness and more discrimination than is presented by the first edition. GEORGE J. ROMANES

OUR BOOK SHELF

An Atlas of Anatomy; or, Pictures of the Human Body, in Twenty-four Quarto Coloured Plates, comprising One Hundred Separate Figures. With descriptive Letterpress by Mrs. Fenwick Miller, Member of the London School Board, &c. (London: Edward Stanford, 1879.)

THIS work has been issued at a comparatively low price in the hope that it may be found useful both to science teachers and to all kinds of students. Children, we have it on the authority of Mrs. Miller, with their keen interest in the facts of Nature and with their fresh undistracted minds full of curiosity about what is around them, are always found to take a deep interest in the wonderful structure and functions of their own bodies. The subjects of anatomy and physiology have been introduced into many of the London Board Schools and have been found wonderfully popular among the children. An Inspector records that he has often been struck with the alacrity with which the children rush to their seats for an oral examination in physiology, even at the end of a long and tiring day of inspection. Truly such children must be very desirous to know all about themselves, and for such no doubt such a volume as this would prove quite an acceptable gift. Nearly all the drawings represented in the plates are new—never before published in any form in England. Some of them are from Dr. Heitzmann's Atlas, others are drawn from preparations in the Vienna Museum of Anatomy. In writing the letterpress the authoress had mainly in view the requirements of young students, and she has not assumed that any of her readers possess any knowledge of the subject. We are not disposed to be critical on a work published with such evidently good intentions. The physiological portions of the text are good, and if thoroughly taught to students and understood by them will place them far above the ordinary standpoint of the medical student of the day. The more purely anatomical descriptions would have been improved if written more for the plates than they have been. The plates themselves will be found extremely useful. We should have preferred that the amount of enlargement of the figures was always given; structures also like those figured at A on Plate xxiv. should be clearly defined as only diagrammatic representations, and a little greater attention to correctness of outline might fairly have been bestowed on the figures representing parts of the skeleton. The letterpress is accompanied by a pretty copious index to the plates, which might even still with advantage be greatly enlarged. This book in the hands of an intelligent teacher will be found most useful and instructive, and it may be made the text from which to preach many a most important practical lesson. Take the short paragraph headed Salivary Glands, how much human suffering might be avoided by a right comprehension of the facts therein stated.

Electric Transmission of Power. By Paget Higgs, LL.D., D.Sc. (London: E. and F. N. Spon, 1879.)

ONE of the important practical questions which an engineer continually has to face is the transmission of power from the place where the power is generated to the spot where the power is needed. Where the distance is great, belts and shafting are not only wasteful but impracticable, and hydraulic or pneumatic transmission is called into play. Here, again, great distances cannot be surmounted without great loss of power, and hence from time to time many wistful glances have been turned in the direction of electricity. It is only to-day, however, that, amid the manifold applications of electricity, its employment as an economical means of transmitting power has become a question of practical importance.

At the Loan Collection of Scientific Apparatus exhibited at South Kensington in 1876, two small magneto-electric machines made by Gramme were to be seen illustrating this electric transmission of power. The mechanical work expended in one machine was converted into electricity, conducted over a considerable space, and transformed again into mechanical work by the other machine. The amount of power practically reclaimable by such an arrangement, as shown by recent experiments quoted in the little work before us, "may amount to 48 per cent. of that expended in the first instance. This amount of reclaimed power is indubitably superior to that obtained with compressed air, and approaches the practical efficiency of hydraulic transmission" (p. 85). With great distances the relative efficiency of electric transmission must be still more marked, besides the advantage that the conductor, having nothing to burst or give way, can be led in any direction or freely moved whilst transmitting many horse-power. Already in France ploughing has been done by electricity with advantage, and where natural sources of power, as waterfalls or tidal action, exist in any neighbourhood, the extreme value to a community of this novel application of electricity is sufficiently obvious. Municipal authorities might find in the water supply of a town an unexpected source of income. For where there is a continuous supply of water under considerable pressure, as is the case in an increasing number of our large towns, baths and washhouses might be erected in the lower parts of the town, and the energy possessed by the water converted into electricity and distributed for sale as power, whilst the matter of the water would of course remain equally serviceable for the purposes intended.

To those interested in the general question of the electric transmission of power we do not know any better guide than Prof. Ayrton's admirable lecture on this subject before the British Association. To the student the work before us will be found useful for more extended reference, as it gives the salient features of the investigations by Mascart, Hopkinson, Siemens, Houston and Thomson, and others, on the efficiency of various dynamo-electric machines. But we regret that Dr. Higgs has issued this book with such precipitate haste, for, as it stands, it is a most slovenly piece of patchwork, and to be of real use to the public it must be in part rewritten and the facts presented in a more intelligible and orderly sequence.

W. F. B.

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.*]

Sun-Spots in Earnest

THE communications in NATURE, vol. xx. p. 625, regarding the note of Prof. Piazzi Smyth, NATURE, vol. xx. p. 602, induce me to send an extract from my observing-book on those spots, together with some observations of them by Herr Hartwig, assistant to the observatory.

My observations of the sun are made with a rather small telescope, aperture of object-glass by Reinfelder and Hertel, of Munich, 74mm., with Merz polarisation eye-piece, power 55, images very fine, colourless.

1879.	M.T. Strassb. h. m.	
October 6	... 0 0	No spot on the sun.
,, 7	... 0 10	On the following limb two great regions of faculæ, with extremely narrow black spots in them.
,, 8	... 1 0	The group of faculæ, seen yesterday, contains to-day three great spots, with double nuclei; besides that there is a fourth system of three or four smaller spots with penumbra.

I did not look at the sun on the following days. The observations of Herr Hartwig are made by projection and with the heliometer of the observatory. By this instrument the polar and equatorial diameter of the sun has been measured every day since April, 1876, clouds permitting. It was during this series of micrometric measurements that Herr Hartwig made his remarks.

	Sid. T. Strassb.	
October 6-7	... 12 50	The sun appears without spots.
,, 7-8	... 12 25	Sun without spots; very bad definition.
,, 8-9	... 12 10	Beautiful group of spots near the following limb.
,, 10-11	... 12 15	Same group of spots, as seen the day before yesterday. Four very great spots; the following, which had *two* nuclei, like the others, has to-day *three*.
,, 12-13	... 13 10	Double spot on the middle of the disk; group of spots on the following limb.

Afterwards the clouds did not permit the sun to be seen for a week. It appears from these observations, that this first great display of solar activity after the minimum of spots, entered the disk October 6-7; it passed off, as Mr. Christie remarks, October 21.

A. WINNECKE

Strassburg Observatory

Subject-Indexes

MOST of those engaged in scientific work will probably agree with the views on this subject put forth by Mr. Wheatley in NATURE, vol. xx. p. 627. There can be little doubt that a complete subject-index of scientific literature, in the sense in which it is generally understood, could not be compiled, and that the result of an attempt to do so would be as useless as it would be cumbrous, for the obvious reason that in a given paper, much valuable work is recorded which served only as a means to the end treated of; this work, therefore, lies hidden under a title which does not even remotely refer to it.

On the other hand, the compilation of lists of papers on particular subjects is fraught with no great difficulty, and would be of very great value. While the preparation of such minor indexes founded on the Royal Society Catalogue may be left to private enterprise, great advantage would, I think, be derived from some united action in the matter. I have myself made considerable headway with a classified list of papers on the subject which chiefly interests me, and which perhaps is best named Molecular Physics. This work necessitates my going through the whole catalogue for the sake of comparatively few papers, and I am further obliged to copy out the titles of, and references to, the papers I require. Now, if a movable copy of the Royal Society's Index were made as suggested by Mr. Garnett (NATURE, vol. xx. p. 554), and the different entries classified in sciences, these difficulties would be removed; Mr. Garnett, however, underrates the cost of preparing such a movable index, which would be large enough to deter many "gentlemen with leisure" from undertaking it. This work, therefore, must be carried out either by the Royal Society, or by a committee of those who take an interest in the subject; when completed the index could be distributed among those willing to undertake the subsequent arrangement in subjects.

There is another suggestion which I should like to make before closing this letter. Every month as it slips by adds rapidly to the enormous accumulation of scientific papers; unless these are catalogued and classified immediately they are published, the subject catalogue will never be satisfactory. What is wanted, then, is the publication (say every quarter) of a *complete* list of the scientific papers published during that period. I am aware that, as mentioned by Mr. Garnett, many such lists now appear, but none of them can be trusted as complete records.

If, however, a list were published "by authority" (for example, by the British Museum or the Royal Society), scientific men all over the world would send the titles of their papers to be entered in it, and it would soon be recognised that those who did not do so would stand a chance of rendering their work useless to those who travel after them along the same paths.

Science Schools, November 3 F. D. BROWN

Easter Island

IN the very interesting review of Mr. Wallace's "Australasia," in NATURE, vol. xx. p. 598, there is a passing reference to some views of my own concerning the stone images of Easter Island. The nature of the inferences that may be drawn in this case is not, I think, generally understood; and without wishing to give the subject more importance than it deserves, I should be glad if you could allow me space for a few words upon it.

Any positive ideas about the people who made them can hardly be got from the images themselves. They are rudely carved and ugly, and no existing race attempts to make anything really like them. But they are very numerous and very large; many of them weigh twenty tons, some probably two or three times as much. They have been quarried from a volcanic hill, conveyed several miles, and set upright upon pedestals, on massive stone terraces of great length. Work of this kind requires a definite amount of labour and strength. The amount available depends on the population. The population of a solitary island inhabited by savages is strictly limited by its area; the area of Easter Island is not more than forty square miles. There is, I believe, no known example in which an island of this kind supports, in an uncivilised state, more than fifty persons to the square mile. This is double the usual limit among savages.

Two thousand, therefore, would be the extreme limit of the population of Easter Island, unassisted from without; it has not more than half this number at present. In a population of 2,000 there are about 500 adult males, and we are to consider whether the work could have been done or even thought of with this amount of physical strength. It is, doubtless, quite impossible. A much larger number of people, or the help of civilised appliances, must necessarily have been at hand; but neither of these could be at hand without external help, and this could only reach the island across two thousand miles of ocean.

This is the really important point in this chain of inferences. We are led by what I think are inevitable steps to the conclusion that when these images were made there was a nation somewhere whose ships navigated the Pacific Ocean in such a manner that Easter Island could for a long period be supported as a colony.

I will not speak here of the anthropological bearings of this inference. Let me, however, enter a gentle protest against the sentence in which your reviewer speaks of "the accepted scientific position that primitive man was savage."

No doubt this is at present the belief of the majority of those who express their views; but there are names of great weight on the other side, and, considering what our actual knowledge of "primitive man" amounts to just now, it is rather hard upon science to make her responsible for our speculations.

November 3 ALBERT J. MOTT

Animals and the Musical Scale

IN a criticism in the *Examiner* of a book of mine on the "Theory of Music," the writer says:—

"We can hardly agree with Dr. Pole's view as to the essential artificiality of the diatonic scale, especially in the light of many facts collected by Mr. Darwin and other good observers. It is now almost certain that several of the lower animals have a very fair notion of the scale, and employ notes almost, if not quite, identical as to interval with our own."

If any of your readers can bring forward well authenticated facts of the kind they will be very interesting.

Athenæum Club, October 29 WILLIAM POLE

John Miers

IN your notice of the late venerable botanist, Mr. John Miers, in NATURE, vol. xx. p. 614, it is stated that "to the last he disbelieved in the action of the pollen and of the pollen-tube in the formation of the embryo-plant."

It is possible that the writer may have had some further warrant for this statement than the views published by Mr. Miers in his memoir on *Myostoma* (*Trans.* Linn. Soc., xxv. pp. 461-475 (1866), but it is scarcely borne out by them.

Mr. Miers's position as there expressed is that "it is not the pollen-tube, but simply the fluid-material contained in the pollen-grain, and emitted from its tubes, which is the direct agent in the process of fertilisation."

Whatever may be thought of this view, it is far from justifying the strong statement that in supporting it Miers "disbelieved in the action of the pollen." HENRY TRIMEN

October 28

[It would certainly have been more explicit had we added the word "tube" to pollen. At p. 468 of the paper cited by Dr. Trimen, Mr. Miers remarked "that the very important fact alluded to (the impact of the pollen-tube on the embryo-sac and the consequent fertilisation of the ovule) has not yet been satisfactorily proved." This was written in 1866. In the same paper "we have it demonstrated that in this case (Myostoma) the theory of the application of pollen-tubes for the fertilisation of its ovules is distinctly disproved."—ED.]

The Howgate Arctic Expedition

CAPT. HOWGATE, U.S.A., having for some years past fruitlessly endeavoured to obtain the comparatively small grant of 50,000 dollars from the American Government, for the purpose of carrying out his peculiar scheme of Arctic exploration, by forming a colony of active and experienced men, with a few families of Eskimos, at the coal-bed discovered some years ago in Lady Franklin Bay, Smith Sound, lat. 81° N., has determined to equip a private expedition on a smaller scale with this object.

A screw-steamer of about 140 tons (cargo measurement) has been bought for Capt. Howgate in the Clyde, has been refitted there, but not strengthened for ice navigation, which is to be done at Washington, and will, wind and weather permitting, sail for America on Thursday, November 6.

As most of your readers probably already know, Capt. Howgate's intention is that the explorers, instead of living on board ship, shall pass the winter in wooden houses taken out on purpose in frames, to be set up near the coal-seam, the party to remain in this locality for two or more years, watching a favourable opportunity of smooth ice or open water to push northward, and occupying their time usefully in making scientific observations, which are still much wanted in that far north region. Balloons, the telegraph, and probably the telephone, may be brought into use. J. R.

Intellect in Brutes

I AM in possession of an intelligent pointer dog, not quite two years old. The manner in which he makes his exit from the garden brought forcibly to my recollection Prof. Möbius's experiment with a pike, as narrated by Mr. Romanes in his article "Animal Intelligence" in the *Nineteenth Century* for October 1878, p. 659. A pike took three months to learn that he could not reach a minnow separated from him by a sheet of plate glass, and after its removal he never afterwards attacked the minnow. As Mr. Romanes says: "the firmly-established association of ideas never seems to have become disestablished." My pointer seems to arrive at an established association of ideas as fixed as the pike, a fact extremely interesting, considering that the dog is much higher in the scale of life than a fish.

The dog, when young, could only escape out of the garden through a small and difficult gap between the gate-post and the fence—a rose one. Some months ago a spar was broken out of the gate, and though the hole thus made was from the ground upwards, and quite large enough to allow of the passage of a large dog through it, yet it never took advantage of it. About a month ago a friend presented me with a young dog of the same variety, and it *at once* discovered the hole in the gate and went through it. But the older dog continues still to use the old gap between the post and the fence, and singularly enough it will see its companion pass through the hole in the gate, and it will even put its head through the vacant space and then turn aside and painfully crawl through the fence gap, which as a young dog it had discovered and used.

The discussion concerning the intelligence of the lower animals carried on in NATURE has interested some of us here. The following, regarding the gnawing of lead by rats, may perhaps interest your readers. Capt. Moir of the 99th Regiment, at present stationed here, showed me three bullets, still in the cartridge (for the Martini-Henry rifle), half eaten away by the rats, at Fort Chelmsford, Zululand. The rodents had made their way into the haversack in which the cartridges were, cut the strings tying the packet of cartridges, tore the brown paper off in which they were rolled, and then nibbled at the balls. These cartridges are made up in thin brass—which in no case was gnawed at. Nearly the longitudinal half of the exposed part of one bullet was eaten away; they had eaten into half the bullet, crossways of another cartridge, and in the third case they had nibbled off the point of a bullet.

It cannot be supposed that they nibbled for nibbling's sake; doubtless the smell of the grease in the cartridges attracted their attention to the haversacks, and the smell of the grease behind the bullets led them to attack the bullets—the only vulnerable point. JAMES TURNBULL

Grey Town, Natal, September 8

P.S.—There is a rat in Natal which, so far as I can gather, frequently carries its young ones before they are covered with hair; the little things cleave to the teats with mouth and feet. Gilbert White mentions that he once met with such an instance in England. I have not secured a specimen of this rat, though I have seen it once, and once only.—J. T.

Centipedes and Bees

As a postscript to Dr. Hutchinson's letters, I offer the following:—

The centipede does not "bite" at all—it makes tiny incisions with its numerous feet, which in themselves cause trifling inconvenience; but, when alarmed, it drops into each some kind of venom that causes intense inflammation (the *modus operandi* I now forget, but a medical friend explained it very clearly). I once had a centipede's nest in or near my bath-room, no less than eleven of different sizes having been killed there. Our first knowledge of them was derived from an infant child of the female servant, who, having been left on the floor there, was found crying and writhing beyond all soothing. When brought to me the child was feverish and restless, the *left* hand specially hot; on removing the little jacket, the fore-arm was found greatly swelled and inflamed, with two rows, less than half an inch apart, of pricks showing white on the delicate brown flesh. Ipecacuanha and eau de luce soon subdued the pain, but it was days before the child was well again. Several other persons also suffered from them, but only in one case was the line of pricks clearly traceable. Once, stooping to take up a water-pot, I felt a little *froissement* about the thumb; looking down, I perceived a centipede fully four inches long, which deliberately crawled across my hand near the knuckles, causing no pain, but a most unpleasant titillation, which continued for some time, though I put the hand in cold water immediately. On another occasion, seeing a centipede on the naked foot of one of the women, I called out to her, "Roho mut" (do not stir), and she similarly escaped all serious injury, while an application of warm oil very quickly removed all irritation. Of course it is only when crawling straightforward and undisturbed that the line of pricks can possibly be detected. On disturbance the animal shrinks up, curls round, and brings a number of them into one spot; at least such was the case the only time I ever *saw* a centipede do mischief; and the same appeared probable on other occasions when I saw merely the after-result.

I remember once, in the jungles of Rohilkund, one of our line of elephants brushed down a bee's nest from an old tree. Some of the nearest men were immediately stung; the servant behind me instantly wrapped me in a shawl I had beside me, then wrapped himself from head to foot in his large Kummerbund, as did all the other men, and off we went at speed to a small river not far off, where the elephants (who had not escaped) plunged themselves to their very backs, as the only mode of getting rid of their little assailants.

I may add that a small black scorpion common in the Dehlie division is very venomous. I have myself seen a case in which its "strike" was nearly fatal to a shepherd of about fifty years of age. MEMORIA

Bone-Sucking—A Habit of Cattle

THE habit of bone-sucking in cattle (NATURE, vol. xx. p. 457) is not peculiar to Natal. The learned Archbishop of Dublin, Dr. Whately, many years since made a most interesting communication to the then existing Dublin Natural History Society on this subject, and stated his observation that animals addicted to bone-sucking invariably fell into an unhealthy state unless the bone was removed from the field. There is a scarcity of limestone, as Mr. Donovan suggests, with us to account for this "bad habit," for such the Archbishop considered it.

Dublin W. FRAZER

IN response to the letter of Mr. H. C. Donovan (NATURE, vol. xx. p. 457), in relation to the habit of cattle in the colony of Natal *chewing bones*, I beg leave to state that many years ago, in a monograph on "Geophagy," I had occasion to put on record a similar habit among the cows in one of the Southern Atlantic States of the United States (*vide Southern Medical and Surgical Journal*, new series, vol. i. pp. 417–444, August, 1845). From this paper I quote (p. 442–443) the following extract bearing upon the question:—

"In confirmation of the importance of inorganic principles in the food, I will here adduce a remarkable fact which has repeatedly fallen under my own observation: The cows which live on the extensive savannas and pine-barrens lying on the north side of the Altamaba River, in McIntosh County, Georgia, subsist upon very coarse species of grasses, which are probably deficient in some of the phosphatic or calcareous ingredients essential to healthy nutrition, for these animals are constantly observed to *chew bones*. They frequently remain stationary for hours, with the head elevated to prevent the saliva from escaping from the mouth; they will, by constant trituration, gradually reduce the bony mass to a very small size, when it is rejected as an unmanageable morsel. The cattle in this section of the state are usually rather lean, and cows brought from the fertile plantations in the neighbourhood, if allowed to subsist on what they can procure in the savannas and pine-barrens in the course of a year or two become equally thin, and ultimately fall into the habit of *eating bones*. I have not been able to ascertain whether these animals indulge in this habit to a *greater extent* when they are in a state of *pregnancy* and when they are giving *milk*, but it appears reasonable that the increased demand for mineral matters under such conditions of the economy would call for a proportionate supply. The intelligent instinct which prompts these animals to seek for a diet so extraordinary must originate in an inadequate supply, in their impoverished aliment, of some of the inorganic principles (probably the phosphatic salts) essential to a proper nourishment of the osseous structures."

Berkeley, California, October 4 JOHN LECONTE

Earthquake in China

THE north of China has been very unfortunate of late. Famine has raged in the provinces of Shantung, Shansi, Shensi, and

Honan within the last three or four years, and, in a less severe form, in one or two of the adjoining provinces. Shansi is still suffering. And now the south-east of the province of Kansah has been visited by a destructive earthquake. The *Peking Gazette* of the 22nd of August states that a memorial has been received from Tso Tsung-t'ang, Governor-General of Shensi and Kansuh, reporting that on June 29 a slight trembling was felt at *Chieh Chow*, and at other sub-prefectures and districts within the province of Kansuh. This trembling, which occurred at first on alternate days and afterwards continued for several successive days, did not entirely cease until July 11. The earthquake would appear to have reached its height on the third day; for Governor-General Tso reports that on July 1 there was a violent shaking accompanied by a noise. A temple, several official residences, and many dwelling-houses were completely destroyed, and many persons were killed and injured.

In the Imperial edict Tso Tsung-t'ang is directed to send officers to the scene of the calamity to hold an investigation into the matter and afford relief to the sufferers. A. H.

Canton, September 13

Vertical Shafts in the Chalk in Kent

In the current number of *Good Words* there is a pleasant, gossiping paper by the Rev. J. G. Wood, giving an account of the curious well-like shafts found in the chalk about Erith. They are 40 feet to 100 feet in depth. Mr. Wood states that the sides show traces of, having been wrought with picks made of deer antlers. He appears to accept the theory of local archæologists that the shafts were executed in "prehistoric" times, in the quest for flints for weapons or for some less obvious purpose.

Under any circumstances I should be loth to dispute the view of so competent an authority, and in this instance I have no local knowledge to guide me; but I should be grateful if some of your readers would satisfy me on the following point:—Is there any instance of similar excavations which have been conclusively proved to be the work of savages ancient or modern? I know of none within my own personal experience.

Burrows on the "adit" or "gallery" principle, *i.e.*, more or less horizontal, can be carried surprisingly far, so long as the roof does not fall in. We see this in the abodes of certain quadrupeds. But, to carry down a *vertical* shaft a few feet in diameter to a depth of 40 feet to 100 feet from the surface, even in a soil as favourable as chalk, appears to me to involve recourse to mechanical appliances not yet observed in use among primitive races. If I am wrong in this matter, the mode of excavation pursued by these rude shaft-sinkers certainly affords interesting matter for study. H. M. C.

London, November 1

THE FUNCTIONS OF UNIVERSITIES

We reproduce with pleasure the following extract from an article on this subject from the *Times* of Friday last, in connection with Prof. Max Müller's address at the Birmingham Midland Institute:—

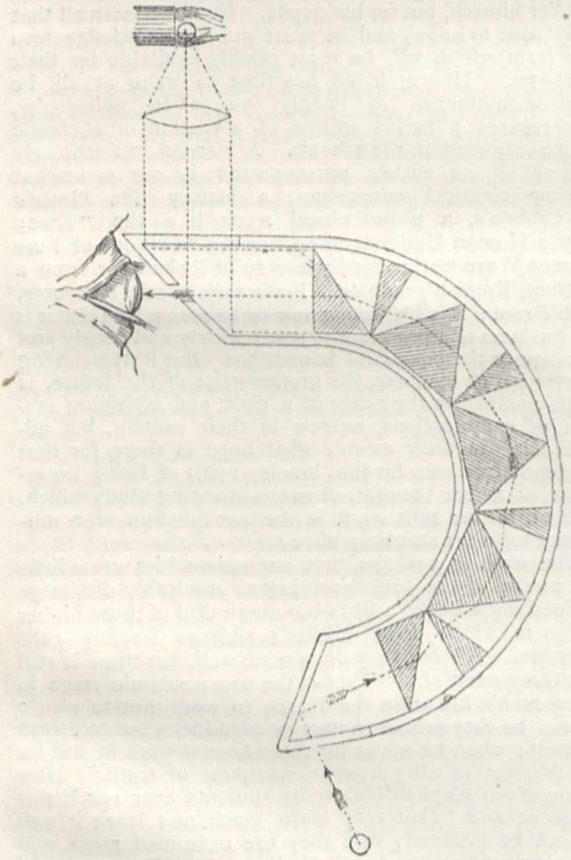
It would doubtless be unjust, as Prof. Müller points out in his address, to attribute the lack of spontaneity, the tendency to mechanical uniformity in academical studies, exclusively to the influence of an elaborate system of examinations. Examinations are clearly necessary, as he justly contends, even though they are no better than a necessary evil; but they are rather means than ends, and they clearly become mischievous when they corrode and destroy the true spirit of academical life. Prof. Müller, a German professor in an English university, whose opinion is on that account entitled to peculiar weight, draws a favourable contrast between English and foreign universities; the former, he says, are free and self-governed, and that gives them an unrivalled position in spite of all their faults. The remark is true and appropriate, especially as a rejoinder to the hasty and ill-considered criticisms of Prof. Helmholtz in his rectorial address at Berlin, delivered some time ago. But the corporate freedom of the English universities, is, unhappily, not inconsistent with a good deal of personal bondage. Let us contrast, for instance, the career of a graduate of a German university with that of an English Fellow of a college. The former, as soon as he has passed the necessary examinations for his degree, is perfectly free to follow his own bent. Even in taking his degree he is entitled to claim it, partly at least, on the ground of some dissertation which he has written containing the results of his own independent study and research. If he elects to follow an academical career, he becomes at first a Privat-docent, and has to attract pupils, not by his power of preparing them for a particular examination, but by his command of all the available knowledge in a special branch of study, and by his capacity for enlarging its bounds. If he is called to be a professor, it is because he is known to be master of his subject, and to be keeping himself on a level with the march of knowledge in relation to it. The English graduade may have all the aspiration to follow this career of true academical freedom; but his pupils for the most part have no higher object than to pass an examination, and it is his business to prepare them for it. Any knowledge that he possesses beyond the range required for that purpose becomes a useless burden to him. The results of fresh research necessarily find their way but slowly into examination papers, and consequently the teacher at an English university, if he studies at all, is bound to study, not for himself, but for his pupils. He must learn all that they want to know, and he must put his knowledge into the form which will be most readily available for their purposes. Hence, if he has time to write at all, he writes summaries of history, essays in philosophy, or prepares a handy edition of a portion of a classic commonly read in the schools. A learned and scholarly edition of an author unrecognised in our somewhat narrow classical curriculum, a history like Grote's or Gibbon's, a philosophical work like the "Essay on the Human Understanding," or the "Critique of Pure Reason," are works hardly now to be looked for from a resident English graduate. Professorial work, of course, is different; it is beginning now to be recognised that it is the business of a professor to study widely and deeply and to advance the bounds of knowledge. But if the coming generation of teachers, the professoriate of the future, is to be confined to the range of a rigid and cramping system of examinations, narrow in their content, but all-embracing in their extent, what hope is there for that academic freedom, for that bracing spirit of living knowledge, of active thought, of ever-advancing study which, as Prof. Müller tells us, it is the true function of a university to foster and keep alive?

The truth is, perhaps, that our universities are a little too careful of the functions they so admirably discharge of finishing schools, a little too unmindful of those higher duties to which Prof. Müller's address forcibly calls attention. All that they do is done well, but there is still one thing needful. "That is the true academic stage in every man's life when he learns to work, not to please others, be they schoolmasters or examiners, but to please himself; when he works for sheer love of work in and for the highest of all purposes—conquest of truth." How many of our English University students ever reach this stage at all? That they learn much and learn it well cannot be doubted, that they are examined much and are examined well is equally indisputable. But we should be very sorry to see the Universities complacently resign the function of making scholars in favour of that of testing the attainments of schoolboys. We are very far from arguing that examinations can be dispensed with altogether. They have their purpose, and it is a very necessary purpose to fulfil. It is their indirect results in stereotyping academical effort, in extinguishing academical freedom, in discouraging wide study, in checking individuality, and in repressing spontaneity, rather than their direct results, that we have to fear The evil is no slight one, and we fear it is still on the increase. "Unless," said Mill, "individuality shall be able to assert itself against the yoke of public opinion, Europe, notwithstanding its noble antecedents and its professed Christianity, will tend to become another China." Prof. Müller would persuade us that our Universities are a safeguard against this catastrophe. But when China is mentioned in connection with education, examinations are suggested by an irresistible association. If, therefore, England is to escape the fate of China, it is not only encouraging to reflect that the most conspicuous modern building in Prof. Müller's own University is the new Examination Schools.

DESCRIPTION OF AN INSTRUMENT FOR EXPLORING DARK CAVITIES WHICH ARE INACCESSIBLE TO DIRECT LIGHT

An electric lamp has recently been proposed for surgical and dental operations.[1] Some years ago I designed an instrument for illuminating the dark cavities of the body which would, I think, be very serviceable in connection with an electric lamp.

This instrument consists of a series of prisms arranged somewhat as in the corona employed for spectrum analysis. The accompanying woodcut will be sufficiently intelligible



without any detailed description. The different prisms are of glass of such refractive indices as to secure achromatism, and the rays of light are bent round corners, so as, finally, to reach an external observer.

In most cases one or two such prisms will be sufficient, but any number may be employed so long as the loss of light from absorption, superficial reflection, and other causes is not so great as to defeat the object in view by destroying the distinctness of the image.

THOMAS STEVENSON

[1] *Engineer*, March, 1879.

IMPROVEMENTS IN BLEACHING

A METHOD of applying the ordinary bleaching agents (hypochlorites) in a new way has been invented by Count Dienheim de Brochocki of Paris. Instead of immersing the goods to be bleached in an ordinary "chloride of lime" vat, and subsequently souring, the inventor treats bleaching-powder with an acid and simultaneously passes air through the mixture, so that chlorine and hypochlorous acid vapours are mechanically carried off; the resulting gases are passed through an alkaline solution in such proportions as to saturate part or the whole of the alkali, or to supersaturate it at will. The resulting liquid is said to be sufficiently stable to be kept without change for two or three months; it can readily be prepared of a density of 30° Beaumé, and acts as a bleacher without requiring any acidulation, and for many purposes is said to be superior to the ordinary bleaching-vat.

To this liquid the fanciful name "chlorozone" has been given, the inventor asserting that the oxidising power of a given quantity of bleaching-powder is *increased* by this treatment through the fixation in the product of some of the oxygen of the air used as carrying agent; the which oxygen he conceives to be liberated in the form of ozone in contact with the goods to be bleached! Although no experimental proof of the truth of this somewhat novel proposition appears to have been vouchsafed to the scientific world, yet it would seem that the new product has at least some practical advantages over the older bleaching agents, as it is used to a considerable extent in Paris, whilst works for its manufacture on a large scale have been recently erected at Warrington by Messrs. Nath. Holmes and Partners.

HERING'S THEORY OF THE VISION OF LIGHT AND COLOURS[1]

III.

In the sixth and last memoir the author develops the part of his theory which has probably excited the most interest, namely, that of the vision of *colours*. He devotes his first section to the *mode of classification* of colours, and as this is not only the most important part, but differs materially from the generally received views, it is desirable to give its substance pretty fully.

He explains that, as he has based his general theory on what are naturally and physiologically two simple sensations, white and black, so he proposes to base his treatment of colours on the "natural system of colour-sensations." He then has to seek what the simple natural sensations of colour are, neglecting in this classification all consideration of the physical properties usually connected with them. He inquires, therefore, what simple colour-sensations there are. Taking the six usually admitted, violet, blue, green, yellow, orange, and red, he finds that two, namely, violet and orange, are obviously compound sensations; for in violet of every hue there can be distinguished clearly a mixture of the two sensations, blue and red; and similarly in orange there can always be traced the elements of red and yellow. The other four colours are red,[2] green, blue, and yellow. None of the sensations known by these names contain, when pure, any semblance of another colour-sensation. These four, therefore, may with perfect correctness, as was pointed out by Leonardo da Vinci, be considered as simple or fundamental colour-sensations. On this account they have received special names, not borrowed from any coloured natural objects.

All other colour-sensations than these may be called mixed or compound sensations, as two elements can always be discovered in them; but it is a fixed principle

[1] Continued from vol. xx. p. 639.
[2] This, however, is not the spectral red, which contains a mixture of yellow.

that *more than two simple colours* can never be evident in the same mixture.

There is also a natural peculiarity in the capabilities of the various simple colours for combining with each other. Red will combine with yellow or blue, but not with green, *i.e.*, red and green can never be both distinguished in the same combinations. Similarly, yellow will combine with red or green, but not with blue. Green will combine with blue or yellow, but not with red; and blue will combine with red or green, but not with yellow. In other words, we find the natural law that *on the one hand Red and Green*, and *on the other hand Blue and Yellow*, are never visible together in the same combination; they are incapable of combining together. What the cause of this is it is impossible to say. It is customary in books on physics to say that red and green, or blue and yellow combined, make white; but this is only true when by red, green, &c., are meant ether vibrations, and not physiological sensations; for to insist that red *plus* green makes white in the same sense that red *plus* blue makes violet would be contrary to common observation, for in pure white there is no trace of any colour-sensation whatever. It must, therefore, be something in the natural connection of these colours with our sense of vision that makes these combinations incompatible with each other; and for the sake of using a short expression for this relation, the author proposes, in consideration of their so-to-speak inimical relations to each other, to call red and green, or blue and yellow *opposite*, or *contrary*, or *antagonistic colours* (*Gegenfarben*).[1]

The combination of any simple colour-sensation with that of another (not antagonistic) gives a sensation of a different *hue* (*Farbenton*), and the hue will vary according to the proportions of the components. Thus different proportions of red and blue will give different hues of violet, and so on. The whole scale of these may be conveniently expressed by a "colour circle." Divide a circle into four quadrants, and at each point of division put one of the four simple colours, arranging the antagonistic ones diametrically opposite to each other. The intermediate portions may then be filled in with compound hues, passing in regular gradations from one of the simple colours to the next adjoining on either side. Such a circle, if supposed to be divided into very minute gradations, will contain all possible hues of colour. And every *hue, both simple and compound, will have, diametrically opposite to it, its natural antagonistic colour.*[1] Now every possible hue of colour may appear in many different states of "purity," or, as it is often called, "saturation." These various states are called by the author "nuances," and they are caused by the mixture with the hue in question of various proportions of black and white, *i.e.*, various degrees of the black-white sensation. Thus red may be mixed with black, white, medium gray, light gray, or dark gray, every grade giving a different nuance of the red hue.[2] The different hues and the different nuances of each taken together will comprise all colour-sensations possible.

The pure colour-sensations are unknown to us; what we experience are always nuances containing white or black. The fact that some colours, and some parts of the spectrum, appear so much brighter than others is due, the author asserts, to the fact of the former containing more white. He conceives that if the pure colour-sensations alone could be experienced they would all be of equal brilliancy, and would probably have the same degree of luminosity as the medium gray; for as each colour-sensation must be considered as an independent one, there is no reason for attributing to any of them the particular effect that we are accustomed to connect with whiteness in particular.

The varieties of colour-sensation admit of being expressed in a formula. Varieties of hue may be expressed by the proportions of each colour they contain; thus $\frac{\text{Blue}}{\text{Red}}$ or $\frac{\text{Red}}{\text{Blue}}$ will express all varieties of violet; the *blueness* of it will $= \frac{\text{Blue}}{\text{Blue} + \text{Red}}$, and the *redness* $= \frac{\text{Red.}}{\text{Blue} + \text{Red.}}$

The nuance of a hue, or its degree of purity, is expressed by the ratio the weight of the pure colour-sensation bears to the whole weight of the combination; thus the purity of a nuance of Blue $= \frac{\text{Blue}}{\text{Blue} + \text{White} + \text{Black}}$. Thus, suppose a red is mixed with double its weight of medium gray, then there are equal weights of each sensation, and the purity will be

$$= \frac{1}{1+1+1} = \frac{1}{3} = 0{\cdot}33.$$

For a compound hue, for example, violet, the purity will be $= \frac{\text{Blue} + \text{Red}}{\text{Blue} + \text{Red} + \text{Black} + \text{White}}$. For example, suppose the weight of the blue and red sensations are 4 each, the white 1, and the black 3, forming a dark nuance of violet, the purity

$$= \frac{4+4}{4+4+1+3} = \frac{8}{12} = 0{\cdot}66.$$

The author further forms an estimate of the *brightness* or *luminosity* (*Helligkeit*) of a nuance by the formula

$$\frac{\text{White} + \frac{1}{2}\,\text{Colour}}{\text{White} + \text{Black} + \text{Colour}}.$$

Thus in the former of the above two examples, the luminosity will be

$$= \frac{1+\frac{1}{2}}{1+1+1} = \frac{1}{2}.$$

In the latter

$$= \frac{1+\frac{8}{2}}{1+3+8} = \frac{5}{12}.$$

[1] The following observations of Sir John Herschel (extracted from his Report on my paper on Colour Blindness, presented to the Royal Society in 1856) strikingly confirm the views expressed by Herr Hering:—

"It is as necessary to distinguish between our sensations of colour and the qualities of the light producing them, as it is to distinguish between bitterness, sweetness, sourness, saltness, &c., and the chemical constitution of the several bodies which we call bitter, sweet, &c. Whatever their views of prismatic analysis or composition might suggest to Wollaston and Young, I cannot persuade myself that either of them recognised the *sensation* of greenness as a constituent of the sensations they received in viewing chrome yellow or the petal of a marigold on the one hand, and ultra-marine, or the blue salera, on the other; or that they could fail to recognise a certain redness in the colour of the violet, which Newton appears to have had in view when he regarded the spectrum as a sort of octave of colour, tracing, in the repetition of redness in the extreme refrangible ray, the commencement of a higher octave too feeble to affect the sight in its superior tones. Speaking of my own sensations I should say that in fresh grass or the laurel leaf, I do not recognise the sensation either of blue or yellow, but something *sui generis*; while on the other hand I never fail to be sensible of the presence of the red element in either violet or any of the hues to which the name of purple is indiscriminately given; and my impression in this respect is borne out by the similar testimony of persons, good judges of colour, whom I have questioned on the subject

"It seems impossible to reason on the joint or compound sensation which ought to result from the supra-position in the sensorium of any two or more sensations which we may please to call primary.

"Declaring red and green to be primary sensations, and yellow a mixture of them [is] a proposition which needs only to be understood to be repudiated—quite as decidedly as that the *sensation* of greenness is a mixture of the *sensations* of blueness and yellowness, and for the same reason; the complete want of suggestion of the so-called simple sensations by the asserted complex ones.

. . . .

"From these premises it would seem the easiest possible step to conclude the non-existence of yellow as a primary colour. But this conclusion I am unable to admit in the face of the facts (1) that a yellow ray incapable of prismatic analysis into green and red, may be shown to exist, both in the spectrum and in flames in which soda is present; and (2) that neither red nor green, as sensations, are in the remotest degree suggested by that yellow in its action on the eye.

"Whether under these circumstances the vision of normal-eyed persons should be termed trichromic or tetrachromic, seems an open question."—*Proceedings* of the Royal Society, vol. x., 1859-60, p. 72.—W. P.

[1] Such a circle has been published by Chevreul, but the colours are arranged somewhat differently, the antagonistic ones not being opposite to each other.—W. P.

[2] In technical language mixtures of a colour with white are called *tints*; with black, *shades*; but this nomenclature is imperfect, according to the author's view, as the various nuances are considered by him to contain black and white together.—W. P.

The luminosity of a pure colour will thus be $=\frac{1}{2}$, and if mixed with an equal quantity of white, it will be

$$=\frac{1+\frac{1}{2}}{1+1}=0·75;$$

that of pure white being 1.

After these preliminary explanations the author proceeds to develop the chief features of his theory of colour-sensation, adopting the principles previously laid down as applicable to black and white only. He expresses the chief points in two propositions :—

1. There are six fundamental sensations of the visual substance, arranged in three pairs. These are—

Black and white.
Blue and yellow.
Green and red.

2. Each of these pairs corresponds to a dissimilation process and an assimilation process of a special kind, so that the visual substance is subject to chemical change, or change of matter, in a threefold way.

The three kinds of change may be either connected or independent; the latter is the simplest supposition, and the author finds it convenient to assume that there are *three different components* of the visual substance, which he considers as corresponding with the three pairs of sensation, and which may, in short, be spoken of as the black-white, the blue-yellow, and the red-green substances respectively.

These three substances are not all present in equal quantities ; the black-white one is much more richly provided in the visual organs than either of the others, and the latter are not present in equal amount.

As in the black-white substance, both dissimilation and assimilation go on, the former corresponding to the white and the latter to the black sensation ; so the same processes take place in the two other substances, but with much less activity, whence the weight of the six fundamental sensations is very unequal ; relatively great in the black and white ; relatively less in the four colours. The author does not venture to pronounce which of a pair of colours corresponds to the D and which to the A action.

All rays of the visible spectrum have a dissimilating action on the black-white substance, but the different rays in different degrees. On the blue-yellow or the red-green substance certain rays alone have a D action, certain others an A action, and certain others no action at all. Thus each of the three substances has, so to speak, its own particular sensation-spectrum ; and in the actual impression of the spectrum these three overlap or intersect each other.

The spectrum of the black-white substance is the brightest in the yellow, and diminishes on both sides.

The spectrum of the blue-yellow substance consists of two parts, one yellow and one blue, which are separated by a spot which is lightless for this substance ; this is the place of the pure green.

The spectrum of the red-green substance consists of three parts, one green in the middle, and one red at each end, giving two spots which are lightless for this spectrum, *i.e.*, the place of the pure yellow and that of the pure blue.

Thus the total spectrum of the visual substance has three distinguished physiological points, where, in addition to the white, only one fundamental colour is visible, viz., yellow, green, or blue. The real red is very small in the spectrum, for the spectral red contains much yellow. The first part of the spectrum from red to pure yellow is thus a mixture of white, red, and yellow ; the second, from yellow to green, is a mixture of white, yellow, and green ; the third, from green to blue, of white, green, and blue ; the fourth, from blue to the end, of white, blue and red. In the pure yellow, green, and blue, only these colours mixed with white are seen.

Mixed light appears colourless, when it acts, on the blue-yellow or the red-green substance, with equal D and A power, for then both effects neutralise each other, and the action on the black-white substance alone appears. For this reason two objective kinds of light, which, when mixed, give white, are not *complementary* but *antagonistic;* they do not produce the white by their combination, but merely destroy each other and leave visible the white which was already there.

The *excitability* (*Erregbarkeit*) may vary, doubly, on each of the three substances in the same manner as before explained, so that one and the same objective light-mixture may not only appear lighter or darker, but varying in colour according to the proportions present of the six kinds of excitability, giving various conditions (*Stimmungen*) of the visual organ.

Suppose the eye to have been long at rest, so as to be in what has been called the neutral condition (the D and A-actions being equal in regard to all three of the visual substances), the total sensation will comprise the two opposite colour-sensations of each colour-substance, as well as the white and black sensation, but the latter will be much the stronger, and more predominant, as each of the colour-sensations will neutralise its opposite one, *i.e.*, the red and green will neutralise each other, and so will the yellow and blue. This neutralising effect, however, does not take place in regard to the black-white substance, because the assimilation causing the black sensation is not produced by any direct rays ; if there were any solar rays causing A-action in the black-white substance, then solar light might, under certain conditions, be invisible, like an equal mixture of blue and yellow, or red and green. Hence the resulting total sensation, when the eye is at rest, is the mixture of white and black, called neutral gray.

Now if, in this condition, we allow the light of any one of the simple spectral colours, say green, to fall on the eye, it strengthens the already present green sensation, and also the white one. The result is a mixed sensation, formed of green, with a considerable mixture of white, and also with some mixture of black, already existing in the neutral gray. Thus it is that even the spectral colours never appear pure, but always obviously contain white and black impurity.

Pigmental colours are still more impure, as they reflect mixed light, in which only certain rays are more or less weakened. To the colour-action of those rays which are hereby unneutralised by antagonistic rays, is added not only the action of such rays on the black-white substance, but also the action of the whole remaining neutral-mixed light which only acts on the black-white sensation.

Mixed light which gives us a beautiful colour-impression may, if colourless light be added, appear entirely or nearly colourless, because the original colour-sensation is already mixed largely with colourless light. Even the spectral colours quickly lose their force and become pale and whitish, when the vision is steadfastly fixed for a time on one of the dark lines, for the excitability of the colour-substance is quickly lowered, while that of the black-white sensation retains its power.

In general the conditions are very unfavourable, in ordinary vision, for the powerful production of colour ; for both on the light and the dark parts the colour-sensations are rendered strongly impure, if not almost entirely suppressed by the black-white action. In the darkened eye, in which the latter has less power, the colour-conditions are more favourable, and hence the after-images are often highly coloured. The most favourable conditions are where the black-white substance has been fatigued by dazzling light, and hence the after-images in such cases often show colours almost more powerful than even those of the spectrum, where, in the original objects, scarcely any colour was appreciable.

It must be always borne in mind that every visual sensation, however it may appear, is really a mixture of all the six fundamental sensations. That one of the six, which has relatively the greatest weight, gives the character and name to the mixed sensation. If any one fundamental sensation is so strong in predominance over all the others, that the latter are not distinguishable, it approaches the idea of purity, which, however, in reality can never exist.

When the visual organ has been for a long time protected from any external stimulus, it assumes, more or less perfectly, that neutral condition in which the assimilation and dissimilation, as well as the D-excitability and the A-excitability are equal for all the three visual substances.

In this state, in order that a mixed light should produce a colourless impression, it is necessary that this light should have an approximately equal assimilating and dissimilating moment, by which is meant the product of the stimulus and the excitability. Such mixed light may be called objectively colourless light.

But the same light will appear, say, greenish, if the red-green substance is no longer in the neutral condition, but has its green excitability greater than that of the red. For in this case the A and D-moments will not be equal, and a small difference will exist to the advantage of the green.

Now when a part of the previously neutrally tuned visual organ has been stimulated by coloured light, the condition of this part will become so altered that the excitability for the perceived colour diminishes and becomes less than the excitability for the opposite colour. Under these circumstances any mixed light which, in the neutral condition appeared colourless, will now appear coloured with the opposite colour. And if a part of the visual organ has been affected, say, by the action of green light, on looking at a blue or yellow surface, the blue or yellow will appear tinged with red.

The phenomena of simultaneous colour-contrast and of colour-induction are explained in the same manner as for the corresponding phenomena in black and white.

It has been seen that by the white illumination of any part of the visual organ, the other parts of it, and particularly those adjoining, are, by the indirect action of the stimulus, darkened; or the sensation of black is intensified; and in a similar way, under the action of coloured light on any part, the sensation of the opposite colour is strengthened in the adjoining parts.

As a consequence of this the relations of excitability are altered; for, according to this theory the sensation of any colour implies also a change of those relations to the disadvantage of this colour and to the advantage of its opposite. If, then, light be allowed to fall on the whole retina, which, under a neutral condition, would be colourless, it now appears coloured; the colour on the previously excited part will be the opposite colour (successive contrast), while that around it will be the same colour as that previously observed (successive induction). In fact, all the phenomena explained for white and black may be, in this way, transferred to the colour-sensation.

The author makes some further remarks on the Young-Helmholtz theory. He admits that the attempt of Young to reduce the great variety of colour-sensations to a small number of physiological variables was a most important step in advance, but he considers that if, as before explained, every psychical result must correspond to some physiological process, the number of fundamental colour-sensations ought, as has been often urged, to be increased to four, and that separate physiological sensations ought to be allotted to white and black. But he considers the great defect of the theory to lie in its only acknowledging *one* kind of excitability, excitation, and fatigue, namely, that which he denotes by D, and that it ignores entirely the antagonistic relations of certain rays to the visual organ; hence it regards the production of white out of "complementary colours" as a result of their mutual combinations, and not of their mutual extinction.

He also remarks on the difficulties of explanation of many phenomena, on this theory, and in particular on the inconsistencies it causes in the attempted explanation of colour-blindness, as shown in the most modern literature on the subject.

In conclusion he gives some remarks on the chief points of his theory, which it may be instructive to repeat here.

The theory, although immediately dictated by a free and unbiased analysis of the visual sensations, is essentially based on certain fundamental principles, taken from the acknowledged phenomena of organic and psychical life, and it is by these principles that the author's views are brought into connection with the doctrines of physiology generally.

With respect to the doctrine of light and colour, the first thing to mention is the natural system of visual sensations, founded on their internal similarity; and further, the grouping of the six fundamental sensations in three pairs of opposite colours.

Next comes, as of fundamental importance, the appreciation of the visual sensations as the psychical correlatives of the nutritive processes, or changes of matter in the visual substance, which leads to the separation of the D and A sensations, and further, to the principle that every D sensation implies a decrease, every A sensation an increase of the visual substance. Corresponding to the three pairs of simple or fundamental sensations are assumed three kinds of D and A processes in the visual substance and three kinds of specific D and A excitability. The colourlessness of mixed light formed out of "complementary" rays, is explained by their antagonistic relations.

Further, here, for the first time the proof is methodically and comprehensively produced that the separate parts of the nervous visual substance are in internal functional changing relationship (*Wechselbeziehung*), which is to be regarded as reciprocally connected with the change of matter; for when $\frac{D}{A}$ is greater on a stimulated part, it is less in the surrounding parts, and *vice versâ*; so that after the stimulus the excitabilities of both parts change in opposite directions.

These propositions and their consequences afford the means of explaining the various phenomena mentioned, but it often happens that several explanations are possible for one and the same phenomenon, and that the decision between them must be reserved for more detailed inquiry. What we immediately appreciate in a visual sensation is the ratio of the corresponding D and A processes to each other, for this determines the *quality* of the sensation. A change of sensation gives only an indication of the change of this ratio, and not of the changes of its two components. Then it is that we have so often the choice between an increase of assimilation and a stoppage or decrease of dissimilation, and *vice versâ*. But the theory itself gives means of determining these, by further and more detailed and intricate investigations; and the author promises future communications by which the details will further be supplied, without as he hopes, any material alteration of the principles he has laid down.

WILLIAM POLE

THE "PARASOL" ANTS OF TEXAS: HOW THEY CUT AND CARRY LEAVES: ORIGIN OF CASTES BY EVOLUTION

IN Mr. McCook's recent investigation (NATURE, vol. xx. p. 583, and *Proc.* Acad. Nat. Sci. Phil., 1879, p. 35) he stated that he observed carefully both the mode of cutting and the system of carrying cut portions of oak-leaves at Camp Wright, and at a vegetable garden near Austin, Texas.

To investigate successfully he found it best to thrust small branches of live-oak into one of the mounds described, near the "gates." These were soon withdrawn, and seen to be covered with "cutters" busily occupied. It was thus possible to examine them at work by the light of a lantern, as it will doubtless be remembered that night is the busiest time with these active ants, supplying their minuteness with a most effective shelter.

The "cutter," usually an ant belonging to the caste next below the "soldier" in size, first grasps the leaf with outspread feet, and begins to cut into its edge by a scissors-like action of her sickle-shaped toothed mandibles. Thus she naturally proceeds, with steady motion, until the mandibles have clipped off a portion of the leaf, having a circular edge, clean cut. The feet turn as the head turns. The cutter sometimes drops, with the piece just cut, to the ground; but probably, if possible, retires when the piece has dropped, to continue her professional occupation. Mr. McCook found at the foot of one tree a pile of cut leaves, to which clippings were continually being added, dropped by the cutters. The carrier at the foot took them up and carried them to the nest. The loading of the cuttings is thus accomplished: the piece is seized by the curved mandibles, the head is raised, the piece is thrown back by a quick motion, seeming to be lodged on its edge within the deep furrow that runs along the entire median line of the head with the exception of the clypeus, and supported between prominent spines on the edge of this furrow and on the prothorax.

The young saplings near the mound at Camp Wright were found almost entirely stripped of leaves by these ants. The great tree (live-oak) near by was in parts stripped to the very top. In beginning work on a tree the cutters seem to aim first at the topmost leaves. They prefer trees with a smooth leaf; they eat grapes, radishes, &c., and can take celery, beet, young maize, and wheat, plum leaves, honeysuckle, and jessamine. Strangely enough, they do not like lettuce, paper-mulberry, figs, cedar, except the buds, when very hard up in winter. A nurseryman, on whose grounds Mr. McCook witnessed the ants at work and the scene of their former exploits, told him that they even entered his desk-drawers, and carried away part of his chewing-tobacco. At another plantation Mr. McCook saw an immense column of the ants engaged in plundering a granary of wheat.

One of the most interesting questions for evolutionists centres undoubtedly in the causes and mode of continuance of the castes or differentiated forms of species like this ant. The worker-castes are sterile, and produced from eggs laid at different periods by the female; and as to a blending of castes by intermediate forms, nothing has yet been seen or proved in the case of the cutting-ant, after careful examination by the microscope. The lowest castes of minims, in all individuals Mr. McCook examined, with special reference to the mouth-organs and eyes, had the same structure in equal definiteness and perfection, as the larger castes. Consequently, Mr. McCook again finds no way of comprehending how natural selection could have produced or preserved or improved these castes. May I suggest that we know as yet too little of the whole life-history of social animal communities, to say nothing of their past history in time, their conditions during long series of years, and the reaction of each community on its surroundings, to assert that any hypothesis of evolution admissible as a *vera causa* in one case is inadmissible in another? We are but on the threshold of the study of the influence of social laws and conditions upon human communities; how can we expect to understand the influence of society and common interests upon specialisation in ants? Yet there are even now several possible ways of imagining the influence of variation and changed conditions to have aided in producing castes. May it not be that the comparative study of *ant-communities* of the same species, or of different species of the same genus will at length furnish a key much more valuable than we yet know? How is it that nations of man rise and fall, increase or decrease? Are not all men of one species? Why are there so many castes? If we cannot answer these questions perfectly, why be dismayed if we quarrel about terms as to the intelligence or reason displayed by various animal forms? There is nothing to be done but for men to wait, study to comprehend the nature of proof, and then patiently investigate. The explanation of all difficult problems will, if we are to judge by the history of science, be very simple, much simpler and more illuminating than the acrobatic or the prejudiced intellects would have us believe.

G. T. BETTANY

NOTES

THE exhibition at Croydon, held in connection with the Congress of the Sanitary Institute of Great Britain, has a peculiarity attached to it which, though it has its advantages, is a disadvantage to the visitor. The peculiarity is that the awards of the judges will not be made known till the day of closing, viz., November 8. At most exhibitions visitors have their attention drawn to objects of high merit by the announcements of the honours the judges have awarded; but here, and this, too, on subjects often affecting their own health, visitors can, even if they care to take that trouble, only form their own opinions, guided by the skilled advocacy of the attendants at the different stalls. If all the objects announced in the catalogue as "essential," "indispensable," "infallibly safe," and "the only ones of the kind made," are really so, then the practical application of sanitary science in households is in a lamentably backward state, even in particulars where those who are our leaders in sanitation would least expect it. It can hardly be supposed, however, that all the exhibits shown have been admitted with the sanction of the Council as illustrations of the subjects discussed at the Institute. There are, for example, music stands, clocks, sausage mincers, billiard registers, weighing machines, mechanical toys, flower scissors, electric pens, nickel-plated goods, pantographs, bells, telephones, china cements, "lightning" knife sharpeners, &c. Some of the exhibits are made on principles that have been repeatedly denounced; for example, filters so closed that the filtering medium cannot be easily and frequently changed are now by our most experienced observers admitted to be unsafe, yet there are some in the exhibition. Traps of certain construction have been likewise denounced, yet they are shown. Ventilators of patterns generally regarded as practically useless, and so-called disinfectants which are only deodorisers, are shown. It might, perhaps, have been well had the exhibition been called one of "Sanitary and unsanitary appliances," and then the visitor would have been put on his guard not to believe in everything shown there. Mr. F. P. W. Essie, C.E., has contributed part of a collection of the materials on which his paper on the dangers of bad plumbing (read at the Congress) was based. It is intended as an unsanitary exhibition, and shows in an alarming manner how some so-called sanitary appliances may become a positive source of danger. Each specimen exhibited "has been associated with death and with disaster in some shape or other." It is a pity no handbook or any kind of guide other than the unclassified list of entries in the catalogue has been prepared. We may be able to return to the subject next week when noticing the list of awards.

AN article in the last number of the *Revue Scientifique* contains an interesting account of Mont Ventoux (1,928 metres high), and of the scheme for erecting a meteorological observatory thereon. The project, which has been prepared by M. Morard, under the direction of M. Bouvier, includes, first, the construction of a carriage road, which will render the summit accessible at all times. The total length will be 19 kilometres.

The observatory will be placed at the very summit of the mountain, on a platform of rock. It will consist of a small round tower, constructed to resist the most violent winds. Every means will be taken to establish an equilibrium of temperature between the inside of the tower and the outer air. The dwelling-house will be built a little lower, on the south slope, and thus sheltered from the mistral which is extremely violent on the summit of the mountain, and indeed has given to the mountain its name of *Ventoux*. A covered gallery of 11 metres will connect the house with the tower, access to which will thus be easy, even in the midst of snow and storms. At the instance of Admiral Mouchez rooms will be reserved in this house for scientific men, who may come in summer to carry on researches in astronomical physics, for which the limpidity of a Provençal sky is so favourable. The difficulties of execution would not appear to be very great, and, in comparing the situation of the future observatory with that of the Pic du Midi, General Nansouty has gone so far as to compare the summit of Ventoux to a sort of earthly paradise. The necessary expenses are calculated at 150,000 francs, and to this all the chief towns of the South-East have already contributed handsomely, their municipal councils having the intelligence to perceive the great practical benefit to be derived from such an observatory.

THE project of erecting a meteorological observatory on the top of the Ballon de Gervance, in the department of Haute-Saone, is progressing favourably. A fortress is being built on this elevated site, and will be finished next year. The garrison will very probably have the care of meteorological observations. A telegraphic line has been already established between the intended station and Belfort.

M. BISCHOFSHEIM is leaving for Nice with M. Garnier, the architect of the opera, and M. Lœwy, the sub-director of the Paris Observatory, in order to inspect the site on which he intends to erect the new observatory, on which he is to spend a sum of 60,000*l*., as we mentioned in our notes some months ago. Before determining on the details of his plan, M. Bischofsheim and his scientific and artistic advisers are to visit the most celebrated observatories of Austria, Germany, and England during this winter.

KING HUMBERT, of Italy has sent a donation of 20*l*. to a committee organised to obtain subscriptions for erecting a statue to Galvani at Bologna. Galvani was born in that city in 1717, where he was a professor in the University; he died in 1798.

THE *Journal Officiel* publishes a decree organising, at the Observatory of Paris, the School of Astronomy of which we announced, a few months ago, the imminent creation. The pupils are to be appointed by the Minister of Public Instruction rom pupils of the Normal or Polytechnic Schools, or graduates in the mathematical sciences. They must be more than twenty-five years of age. They are to receive 6*l*. a month during two years, and reside in the observatory. They will be obliged to follow courses of lectures at the Sorbonne and Collége de France. The Astronomers of the Observatory will give them special instruction. After having passed their examination, they will be appointed *aides-astronomes* in any of the Government observatories, with a salary of 10*l*. monthly. During their stay at the observatory they will practise calculations, meridian, and physical astronomical observations. *Elèves libres* will be admitted under a certificate of efficiency.

MR. C. L. WRAGGE, F.R.G.S., of Cheadle, has presented to the town of Stafford an excellent collection of specimens obtained by him in his travels in various parts of the world, and which will, no doubt, prove of great value to all those interested in geology and natural history.

IN the Cassel State Library, as well as in the Archives at Hanover, Dr. Geiland has succeeded in discovering a whole series of important original letters, hitherto not known, from the pen of Leibnitz, the philosopher, and of Papin, one of the inventors of practical applications of the power of steam.

RUSSIAN papers publish the project of the Exhibition of Manufactures and Fine Arts, which will be opened in 1881 at Moscow. We learn that the Moscow Anthropological Society and the University propose to take an active part in it, and to give to the exhibition a scientific value.

WE learn that in the month of January, 1880, an artistic and scientific exhibition will be opened in Algiers. It will be the first which has been ever held in the colony.

THE Society of Anthropology of Paris has received, at its last meeting, a letter from Felyx-Denys-Rapontayabo, a native King, in the Gaboon, who, having been educated in the Catholic mission, is a tolerably good French scholar. His Negro Majesty is sending to the Anthropological Society the skeleton of a gorilla, and volunteers to send any scientific documents which may be required.

IN his last report from Saigon, Mr. Consul Tremlett alludes to his having been ordered by the Foreign Office to procure and send home a quantity of the bark known as *hwang-nao*, which during the past four or five years has been exported from Tongking to Trinidad, and there seems to have proved efficacious in cases of leprosy. The tree from which it is obtained is hardly known except to the missionaries, and is only found in the mountain forests of the north of Annam.

A VIOLENT shock of earthquake is reported to have occurred in West Cumberland at 5.30 A.M. on Saturday week. A vivid flash of lightning was seen at the same time. The shocks of earthquake in the southern districts of Hungary, some lasting from forty to fifty seconds, continue in a north-easterly direction, and keep the population in a state of alarm. A shock of earthquake in the direction from south-west to north-east, was felt at Ekaterinodar, Caucasus, on October 9, at 8h. 55m. P.M.

THE Municipal Council of Paris has decided that artificial cold should be applied to the mortuary, in order to keep corpses in a state fit for public inspection and possible recognition for a longer period. In compliance with that decision a Commission, presided over by M. Vauthier, an engineer of the Ponts-et-Chaussées, who resided long in England, has been appointed to report upon the several ice-manufacturing machines. The work of the Commissioner is by no means an easy one. The pneumatic process is not, so far as we are informed, to be brought into the competition. The ammoniac, the chloride of methyl, and the sulphurous acid processes are then to be brought under consideration. The two last methods are now exhibiting at the Champs Elysées Palace, and the ammoniac process is used in the largest Parisian ice-house, the "Glacière du Bois de Boulogne."

A RETURN by the Director of Administrative Statistics at Vienna (based on the latest census of the great European states) shows that out of 102,831 persons who lived over ninety years, 42,528 were men and 60,303 women. The longevity of women is yet more apparent when we consider the numbers of human beings who attain and live beyond 100 years. In Austria, there were 229 women centenarians to 183 male ditto; in Italy, 241 female to 141 male; in Hungary, 526 female to 524 male, &c.

IN a recent Consular Report on the trade and commerce of Benguzi the sponge fishery is described as being entirely in the hands of Greeks belonging to Kalimnos, Hydra, and other islands, who annually frequent the coast of the Gulf of Sidra during the months of August and September. This branch of industry affords employment to upwards of 200 small vessels. A diving apparatus is used in fishing for sponges; the produce during the season is between 25,000 and 35,000 sponges. A duty of 40*l.* is levied by Government on each diving apparatus and 10*l.* on every vessel not carrying that appliance. The produce of the sponge fishery last year was estimated to be worth about 15,000*l.*, and was exported chiefly to England.

MESSRS. FRANCIS AND CO., of Hatton Garden, have recently devised an extremely useful telegraphic arrangement for ships, by which instant communication is given by the captain or officer of the watch to the helmsman. For the navigation of rivers and small waters such means of rapid telegraphing with the man at the helm must be invaluable, as in an instant an order can be given, and that, too, with absolute certainty. A leading and important feature in this new invention is that the signals to every part of the ship can be given from the one instrument, which is in form like a handsome capstan, with the commutators so arranged horizontally around its head that it may be worked by any one without the least instruction.

A COURSE of elementary lectures in continuation of a description of the solar system will be delivered in the theatre of Gresham College, Basinghall Street, London, E.C., on the evenings of November 11, 12, 13, and 14, by the Rev. E. Ledger, M.A., F.R.A.S., Gresham Professor of Astronomy. The lectures will be delivered at 6 o'clock P.M., and will be free to the public. They will be illustrated by means of a lime light.

As we have announced, the three Parisian telephonic companies have entered into a working arrangement, and are busy settling the details. In consequence of this fusion the subscriptions have ceased to be received, the future common price having not yet been agreed 'upon. It is certain that it will be dearer than the cheapest, and cheaper than the dearest. According to every probability 600 francs a year for a single line.

THE gold discoveries in the north of New Caledonia are reported to be turning out very valuable.

FROM Japan we hear that the manufacture of sulphuric acid is now being extensively carried on at the Osaka Mint, and large quantities are exported to China.

THREE boa-constrictors, found in the Chinese island of Hainan, have lately been presented to the Botanical Gardens at Hong Kong.

WE learn from a report on the trade and navigation of New York for 1878 that grape-sugar is being largely manufactured at Buffalo, three large factories have been established for the manufacture of glucose in a solid and liquid form, 200,000 to 300,000 bushels of corn being used in them per month. This product has a ready sale and is largely exported to Europe and other countries, and the business is said to be a very profitable one.

THE principal papers in the Thirteenth Annual Report of the Aëronautical Society are on the Flight of Birds, by Mr. Brearey and Mr. H. Sutton.

THE report of the meeting of October 17 of the Eastbourne Natural History Society contains a paper "On the Additions to the Fauna and Flora of the Cockmere District during the past year," by Mr. F. C. S. Roper.

THE additions to the Zoological Society's Gardens during the past week include a Weeper Capuchin (*Cebus capucinus*) from South America, presented by Mr. A. Sargent; a Silver Pheasant (*Euplocamus nycthemerus*) from China, presented by Mr. R. Moon; three Common Boas (*Boa constrictor*) from Bahia, presented by Mr. W. Young; a Bosman's Potto (*Perodicticus potto*) from West Africa, four Pied Wagtails (*Motacilla yarrellii*), British, purchased.

OUR ASTRONOMICAL COLUMN

MINOR PLANETS IN 1880.—In the first half of the ensuing year three out of the four older minor planets, viz, *Ceres*, *Pallas*, and *Vesta* will come into opposition while not far from perihelion, and consequently their angular diameters and brightness will be about as great as they ever can be, thus :—

Pallas	in opposition on	Jan. 12	will be in perihelion on	Feb. 23.
Ceres	,, ,,	Feb. 12	,, ,,	Feb. 18.
Vesta	,, ,,	June 2	,, ,,	June 19.

At opposition the brightness of *Pallas* will be 6·8m., that of *Ceres* 7·3m., and that of *Vesta* 6·0m.

Perhaps advantage may be taken of the favourable conditions attaching to the positions of these planets to ascertain if they do really present measurable disks as has been stated by Lamont in the case of *Pallas*, and by Secchi in that of *Vesta*. Lamont, soon after the mounting of the 11-inch refractor at Munich, on a night of exceptional clearness, found that *Pallas* presented a defined disk, which at the mean distance of the planet from the sun would subtend an angle of 0″·51, which would correspond to 1″·41 at the distance unity. Again, Secchi observing on nights near the opposition of *Vesta* in 1855, noted a disk a little less than is presented by Jupiter's first satellite, or about 0″·8, which at the earth's mean distance from the sun would subtend 1″·01. There is a third instance in the case of one of the more-recently discovered planets, *Iris*, which at the close opposition in the winter of 1866, was measured by Mr. Talmage with Mr. J. G. Barclay's 10-inch refractor at Leyton; he found the apparent diameter 0″·96, or the diameter at distance unity 0″·89. Hence we should have for the real diameters 630 miles for *Pallas*, 450 miles for *Vesta*, and 400 miles for *Iris*, dimensions beyond those which have been attributed to them on other grounds. The south declinations of *Pallas* and *Vesta* will render them fitting objects for examination at Melbourne should Mr. Ellery be disposed to try the powers of his great reflector upon them. *Ceres* will be well observable in this hemisphere.

While writing upon minor planets it may be mentioned that their number has now been increased to 207; a circular from Prof. Peters, of Kiel, notifying the discovery of four new ones at Clinton (New York) and at Pola, by Prof. C. H. F. Peters and Herr Palisa.

THE RED SPOT UPON JUPITER.—Dr. O. Lohse, of the Physical Observatory at Potsdam, who has watched this planet regularly during the last nine years, mentions that on June 5, when his observations of the present year commenced, the red spot was of an intensity of colour to be perceived at the first glance at 15h. m.t., when it was near the eastern limb. The sharp outline and the form of the spot appearing to offer an advantageous opportunity for another determination of the time of rotation, numerous estimations and some measures of its position and size have been made at Potsdam. Dr. Lohse does not refer to any suspicion of proper motion, of which we have heard elsewhere, but, on the contrary, states that, with the rotation-period, 9·9221h., added on to the epoch 1879, September 27, at 9h. 48·3m., Berlin M.T. (or 8h. 54·7m. G.M.T.), the successive times of transit of the middle of the spot over the central meridian may be obtained. From sensible variation in the intensity and tint near the centre and limbs of the planet he conjectures the superposition of very dense gas or vapour. As the spot exhibits remarkable permanence, it may be also observable next year, and thus be the means of fixing the period of rotation with precision. Dr. Lohse further notes that this remarkable appearance upon the disk of Jupiter takes place at the time of recommencement of activity in the solar atmosphere.

A STANDARD CLOCK AT THE OBSERVATORY, STRASSBURG.—Those who give attention to horological matters will note with interest a communication from Prof. Winnecke, Director of the Imperial Observatory at Strassburg, on the performance of a clock constructed for that establishment by Hohwü, of Amsterdam. The observed rates between 1875 and 1878 are exhibited in tabular form, and are compared with rates calculated from a formula which Dr. Schur has investigated, viz. :—

$$\text{Daily rate} = \overset{s.}{0{\cdot}000} + \overset{s.}{0{\cdot}0125}\,(b - 750) - \overset{s.}{0{\cdot}0110}\,(t - 20),$$

where b is the height of the barometer in millimetres and t the temperature in the clock-case expressed in degrees of Celsius. The tabular statement (*Ast. Nach.*, No. 2,282) is much too long to be reproduced here, but we make the following extract showing the observed and computed rates applying to the two-months' interval, May 3–July 3, 1877; in the first column are the daily rates given by the observations, and in the second those resulting from the above formula:—

	s.	s.
May 3–11	− 0·07	− 0·02
11–25	0·00	+ 0·01
25–31	− 0·04	− 0·04
May 31–June 8	+ 0·03	+ 0·06
June 8–15	− 0·04	+ 0·01
15–19	+ 0·20	+ 0·23
19–22	− 0·15	− 0·09
22–26	+ 0·10	+ 0·11
26–29	+ 0·09	+ 0·05
June 29–July 3	− 0·05	− 0·04

Dr. Winnecke remarks that upon the experience in the interval 1875–78 he believes the performance of the clock has not been hitherto excelled, and congratulates himself upon the possession of a work of art.

PHYSICAL NOTES

WHO did discover the attraction caused by the vibrations of sounding bodies? Prof. Guthrie and Herr Schellbach of Berlin, discovered it independently of each other nearly ten years ago. But Guyot had observed the phenomenon before them; and in a paper in the *Philosophical Magazine* for 1849, by Mr. Reuben Phillips, on the "Electricity of Steam," the attraction caused by vibration is recorded as a new fact.

THE transverse vibrations of metallic cylinders open at one end have been recently studied by Herr Fenkner, at Marburg (*Wied. Ann.*, No. 9). The following results were arrived at: The vibration-numbers of the tones of such cylinders are independent of the height of the cylinder. The vibration-numbers of the corresponding tones of two such cylinders are inversely as the squares of the circumferences (or radii), and they are directly as the thicknesses of metal.

PROF. TÖPLER, of Dresden, is well known to physicists by his researches on singing flames and by the induction electric machine which bears his name. Töpler's machine, of which several examples were shown in the Loan Collection at South Kensington in 1876, resembles in form the more familiar machine of Holtz, and is based upon similar principles. Prof. Töpler is at present engaged upon the construction of a larger machine having twenty rotating plates; and which is capable of generating much larger quantities of electricity. This machine bears a close resemblance to the variety of Holtz machine shown before the Physical Society a few months ago by Mr. W. J. Wilson, and to that recently constructed by Mr. Ladd, which also had a number of plates rotating on a common axis.

APPARATUS for projection, like the magic-lantern, always gives inverted images. Most commonly this causes no inconvenience, for one can invert the object; but there are cases in which this cannot be done, and the only resource is to rectify the image. To obtain this result, M. Duboscq (*Journal de Physique*, October) has recently conceived the idea of receiving the rays which would go to form the inverted image on a prism with total reflection. Suppose an isosceles rectangular prism, placed with hypothenuse parallel to the optic axis of the lens by which the rays from the object are made convergent, and so as to receive the cone of rays on one side; refracted in the prism, the rays reach the hypothenuse at an angle greater than the limiting angle, are totally reflected, and sent to the second side of the prism, where they are refracted at the same angle as on entrance, and then go to the screen, forming an image which corresponds in position to the object. As it may be desired to rectify the image in some other plane than the vertical, it is found advantageous to mount the prism in a tube forming part of the projection-apparatus, and capable of being turned round the direction of the ray.

IN a recent memoir on the plasticity of solid substances (*Rev. Scient.* xi. 1879), Signor Marangoni, with reference to Bottomley's experiment dividing ice with a wire, groups plastic substances in two classes. Those of the first class can be cut in two with a metallic wire like ice, and they can also be considerably deformed. Such are plastic clay, fresh soap, camphor, black pitch. Substances of the second group give two lamellæ on the two sides of the cutting wire, which then come out of the slit, become notched and bend over, resembling leaves; to this class belong vegetable Japanese wax, dry Marseilles soap, tallow and stearine, but above all, yellow wax and paraffin. The occurrence of these phenomena depends largely on the diameter of the wire and on the temperature. For yellow wax, wires of ⅓ to 1 mm. diameter, for paraffin ½ to 0·9 mm. are necessary. With the former, the leaves are formed between − 8° and 40°, with paraffin (melting at 43·5°) only up to 15°. To produce the lamellæ, different weights should be hung to the wire in different cases. The lamellæ are very similar to those separated from rails when a locomotive with strong brake applied, goes quickly down a steep incline.

THE forms produced in the phonograph by utterance of the Italian alphabet are studied in a recent paper by Signor Fautrier (*Atti del Aten. Ven.* [3], I., 1879). The vowels uttered in the A note of the violin (435 vibrations) gave generally three-pointed groups, presenting certain differences. With regard to the consonants, it appeared that with the exception of *l*, *m*, *n*, and *r*, which give characteristic impressions, they only modify the form of the impression of the following vowel, and especially at its limits. Signor Fautrier adds some general considerations, especially on the intensity of the "klangs" given by the phonograph, and the theoretical significance of the apparatus.

M. GASTON PLANTÉ, whose researches on voltaic electricity, especially on the construction of secondary batteries and on the phenomena of their discharge have been from time to time laid before the readers of NATURE, has just published the first instalment towards a second volume. The forty pages or so of this *brochure* treat of the effects obtained with M. Planté's rheostatic machine.

DR. KÖNIG, the well-known constructor of acoustical apparatus has just completed a new instrument which promises to be of great interest and importance. Dr. König has long maintained, in opposition to the theory of Helmholtz, that the "combinational" or "difference" tones produced by the simultaneous sounding of two simple tones of different pitch are the result of very rapid "beats." The new instrument, which has not yet been seen outside M. König's *atélier*, is a kind of modified syren which puts the question at issue to a direct and crucial test.

WE learn that Prof. Silvanus Thompson is engaged upon a monograph upon the subject of Binaural Audition, which will embrace the whole existing literature of the subject. The work will not be published before next spring.

THE magnets employed in Gower's form of the Bell telephone are of unusual strength. It is stated that the steel of which these magnets are constructed is made from the iron of Alvarre, which, though a particularly bad iron for most purposes, makes a steel unsurpassed for magnetic apparatus.

THE phenomena which occur when the retina is struck by intermittent coloured light (alternating with total darkness) have been recently studied by Signor Cintolesi (*Ann. di Oftalmol.*, II. and III., 1879). With a certain velocity of intermissions the field of vision appeared at first still and regular in the colour of the active light. The state is gradually changed, and, *e.g.*, red passes by orange, yellow, and green, into a saturated blue-green, after which there is a return by the same colours to red, and so on in periodic change. This phenomenon of a periodic change with the complementary colour the author also describes in the cases of green and blue. The velocity of intermissions must reach 0·11 sec. for red, 0·14 for green, and 0·15 for blue light. In his theoretical views Signor Cintolesi has recourse partly to the Young-Helmholtz hypothesis, partly to Plateau's oscillation theory, and partly also to the photo-chemical properties of the retina.

IT has been noted recently by M. Jannetaz that, if a fine needle be turned round on a cleavage plate of gypsum (1 mm. to 2 mm. thick) so as to produce a small hole, and then be gently pressed into the plate, a separation occurs, surrounded by Newton's colour-rings, and having the form of an ellipse. The major axis of this ellipse makes an angle of 49° with the fibrous fracture, and its length is to that of the minor axis as 1·247 to 1. This ellipse has the same orientation and relative size as that of the propagation of heat in gypsum. Further, the larger axis corresponds with the direction of greatest resistance to bending, and the greatest elasticity.

EDISON's new electromotor, with which he proposes to drive sewing-machines, watchmakers' lathes, and other light machinery, has an armature resembling that of a Siemens dynamo-electric generator, but placed longitudinally between the limbs of a horse-shoe-shaped electro-magnet. A similar disposition was previously employed by M. Marcel Deprez in the excellent little electromotors shown by him before the French Physical Society last year.

IN the latest pattern of telephone transmitter sent by Mr. Edison to this country, the button of compressed carbon derived from paraffin-smoke has been abandoned in favour of another device. A small rod of ordinary hard carbon, of the quality used in producing the electric light, is mounted behind a mica disk and adjusted in loose contact with a light spring faced with platinum. This arrangement is therefore nothing more or less than a *microphone* attached to the back of a disk which receives the vibrations of the voice.

AT a late meeting of the Académie des Sciences, M. Wardon made a suggestion to substitute nickel for steel as a material for compass needles. M. Wardon adopts a circlet of the metal of a form similar to that devised by M. Duchemin. When the apparatus was submitted under the direction of the Ministère de la Marine to a comparative trial with that of M. Duchemin, it was found to be decidedly inferior for nautical purposes; for the oscillations of the magnetised circlet are extremely slow, owing to the comparatively feeble intensity of magnetisation of nickel.

GEOGRAPHICAL NOTES

AT the last meeting, October 15, of the Russian Geographical Society, the Secretary, M. Sreznevsky, read a detailed report on the geographical work done during the past summer. After having spoken of the gallant geographical feat of Prof. Nordenskjöld, he sketched the results of the expeditions of Col. Prshevalsky, MM. Potanin, Alferaki, and Pyevtsoff, and of the expedition engaged in exploring for the Central Asian Railway. As to ethnography and statistics, the secretary mentions the researches by M. Kuznetsoff in Western Russia, by M. Syrkou in Bulgaria, the anthropological researches of M. Meredlenovsky in the Crimea, M. Polyakoff in the Ural Mountains and Caucasus, M. Kibalchich on the banks of the Dnieper, and M. Miclucho-Maclay in Australia. As to this last, the Society engaged him to return to Europe, for the publication of the very rich results of his explorations, but he prefered to take part in a zoological exploration undertaken by Australian naturalists. The pecuniary position of M. Maclay is a very critical one. After having undertaken his extensive travels without sufficient means, he has received from the Society about 7,000 roubles, which sum was certainly quite insufficient to meet the great expenses necessitated by these travels. Now he has contracted debts for about 15,000 roubles at the Singapore bankers, and the Society seeks private subscriptions, the means for paying these debts, in which it is supported by the opinion of the whole of the Russian press. Finally Prof. R. Lentz made a communication on the labours of the International Conference in the Meteorology of the Polar regions. The Geographical Society will take an active part in the organization of the meteorological stations in these regions.

THE *Moscowskiya Vyedomosti* has received the following information as to the Amu-darya expedition, dated Katty-kourgan, October 19. At Termez the expedition was divided into two parts: one has gone in boats down the Amu to Fort Petro-Alexandrovsk, the other through Surkhan and Rafiuaghan rivers to the Vaksh river. The results of the expedition are important: it has explored the Amu-Darya throughout its length, and its two branches, the Vaksh and the Pyandj rivers, for fifty miles above their junction. The topographers have prepared maps of these parts of the two rivers, and completed the maps of the Amu by several details; several latitudes and longitudes are determined astronomically, and zoological collections obtained. A levelling of the Amu is made up to Chardjuy. We notice the appearance of a Russian work by M. Lokhtin, "The Amu-Darya River and its former Connection with the Caspian." It contains a description of the river, a sketch of the historical data as to the Amu, and a review of the hypotheses as to the causes of the changes of its bed; it is accompanied by a map. The third, fourth, and fifth volumes of the "Report of the Amu-Darya Expedition," contain reports by M. Zuboff on hydrographical works in the lower parts of the Amu-Daria; by M. Dorandt, on the astronomical, magnetical, and hydrometrical measurements; and by Prof. Schmidt, on the slime of the Amu River.

THE death, from paralysis, in India, is announced, of Major Herbert Wood, author of a well-known work on the Aralo-Caspian Region, on the hydrography of which he contributed several papers to this journal.

THE last number of the *Isvestia* of the Russian Geographical Society, contains the proceedings of a meeting of the Society in October, 1878, and several interesting papers:—By M. Prshevalsky, on the observations of Dr. Richthofen; by K. Scharnhorst, on the barometric measurements of heights in Central Asia; by M. Mayeff, on the upper parts of the Amu-Darya, according to the description of Ibn-Dast; and by M. Miclucho-Maclay, on the Agomes Islands. The notes contain information as to the travels of MM. Prshevalsky, Nordenskjöld, and Grigorieff. In the note by Colonel Scharnhorst, on the barometrical measurements of heights made by M. Prshevalsky during his journey to Lake Lob-Nor, the measurements being calculated by comparison with barometrical observations at Nukus and at Omsk, the heights of which above the sea-level are exactly known from geodetical measurements, they are trustworthy, and the error does not exceed 100 feet. The height of Tashkend, calculated by comparison of six years' barometrtcal observations with those made at Omsk, Kazalinsk, Nukus, Petro-alexandrovsk, Baku, and Astrakhan, is 1,516 feet. The other places of general interest are: Kuldja, 2,080 feet; the passes across the Narat and Yuldus Mountains, 10,370 feet and 10,040 feet; the junction of Khabtragay and Baltangay Rivers, 5,320 feet; the town of Kurl, 3,240 feet; Lake Lob-Nor, 2,500 feet; Lake Sayram, 6,920 feet; and Guchen, town, 2,310 feet.

WE are glad to notice the appearance of an "Annuaire for Turkestan" (*Turkestanskiy Kalendar*) for 1880, which contains much useful information as to the mineral riches of the country, its meteorology, financial situation, and statistics, besides a route-map and a map of the general-governorship of Turkestan. We learn from this Annuaire that Turkestan possessed in 1877 only thirty-five schools, with 1,848 scholars.

THE November number of the Geographical Society's periodical contains three short papers: Notes on the Topography of the Sierra Nevada of Santa Marta, U.S. of Columbia, by Mr. F. A. A. Simons; Exploration of Oregon in 1878 by the Wheeler Survey; and Pévtsof's Expedition in North-West Mongolia, by Mr. E. D. Morgan. The first-named is illustrated by a map, which is not particularly well lithographed. The geographical notes, however, are the chief feature of the number. The Dutch Arctic Expedition claims the place of honour, and two pages are devoted to Dr. Holub's career. There is also a long account of the native territories south of the Zambesi, abridged from a report to Sir Theophilus Shepstone, which embodies information hitherto unattainable, and the more valuable as it has been revised by Dr. Holub. The exploration of the Swat River by the *Mullah* is recorded. The concluding thirteen pages are taken up with notes on new books and new maps, the map part bearing a close resemblance to a catalogue.

MR. STANFORD has published a new Library Map of the World, on Mercator's projection. The size is 5 feet by 3 feet, and has several new and admirable features. The currents in the ocean are shown by strong blue waved lines. The areas occupied by these currents, which are chiefly caused by the great periodical winds, have an oscillating boundary or limit, as waved lines are better calculated to indicate this, than the firm and sharply defined lines frequently used. A few of the lines in each current have arrow heads to indicate the direction. Figures in blue upon these waved lines, give the maximum and minimum rates in nautical miles per twenty-four hours. These are selected, we believe, from innumerable observations that have been registered and examined by Captains Evans and Hull of the Hydrographic Department, and published in their invaluable "Wind and Current Charts." The drift currents in the Indian Ocean and China Sea change with the Monsoon winds, and in the chart they are shown as they flow during the south-west monsoon, which blows from April to September. The trade and monsoon winds are named over the map in red letters, and the areas over which they generally blow are tinted in colours. The areas over which north-east winds blow are coloured blue, the areas for south-east winds pink; other areas are differently coloured in accordance with the particular direction of the winds which blow over them. A graduated scale at either side of the chart shows the sun's progress to and fro between the tropics; to the left of the chart the sun's vertical action may be traced as he proceeds northward to the Tropic of Cancer, and to the right, his return journey southward to the Tropic of Capricorn. Dates are given at intervals of five days, the intervening days being indicated by small red dots. In spare spaces to the north of the chart, small inset maps have been drawn to give the completion of the geography in the Polar areas, and upon these will be found, indicated by colour, the average summer limit of open water as far as known. The curves of equal magnetic variation are also shown upon these small maps, and the spots known as the magnetic poles are named. The northern limit of woods, beyond which trees are unknown, is shown upon the small map of the Arctic regions. The principal ocean mail routes are shown by broken black lines, and upon the longer lines the names of ports of departure and arrival are named. The number of days, the average of numerous voyages is noted on each line, and the distances in nautical miles from port to port are also given. The submarine telegraph cables are shown by strong black lines with dots at short intervals, and the various cables to the United States are identified by having their dates attached. The land is coloured politically giving the most recent territorial divisions, and a bright red colour is reserved for British possessions, which enables the reader to see easily how frequent are the stepping stones of British territory over the face of the earth. Altogether it will be seen this map is well calculated to serve a great variety of useful purposes; its execution is all that could be desired.

Dr. Nachtigal has received a telegram from Malta to the effect that Herr Gerard Rohlfs's expedition, having reached and explored the Kufara Oasis, was there set upon and plundered. Herr Rohlfs and Dr. Anton Stecker were consequently compelled to return to Benghazi, though they hoped to receive help and compensation from the Turkish Provincial Government.

Trübner and Co. will shortly publish a new work on Madagascar, under the title of "The Great African Island: Chapters on Madagascar," by the Rev. James Sibree, jun The work will contain a popular account of recent researches in the physical geography, geology, and exploration of the country, and its natural history and botany; and in the origin and divisions, customs and language, superstitions, folk-lore, and religious beliefs and practices of the different tribes. It will contain physical and ethnographical maps.

Geologists will be glad to learn the appearance of a trustworthy map of mines in Russia in Europe by Prof. W. Möller, "Carte des Gites miniers de la Russie d'Europe."

We notice in the last number of the *Bulletin* of the Belgian Geographical Society a paper on the colour of eyes and hair in Belgium, by M. Vanderkindere, with maps: on the Zambeze, by M. Wauters; and the quarterly report on the demographical and medical statistics.

The Church Missionary Society a short time back entertained the idea of establishing a sanatorium on the west coast of Africa, and the matter, it may be remembered, caused some discussion between their adviser, Capt. R. F. Burton, and the Rev. T. J. Comber, a Baptist missionary, at one of the Geographical Society's meetings last session. It was proposed to place the sanatorium on Mount Cameroons, which rises to a height of over 13,000 feet, just in the angle of the Gulf of Guinea, opposite Fernando Po. Two agents of the Society accordingly proceeded thither in the missionary steamer *Henry Venn*, and ascended the mountain to the highest peak. Their report was favourable to the suitability of a spot some 7,500 feet high, known as Mann's Spring, but to build a residence there and cut a road to it would, it appears, cost more than the Society can afford in order to recruit the health of their missionaries.

Under the heading of ethnography, a paper by Père Petitot, on the Asiatic origin of the Indians of Arctic America is commenced in the current number of *Les Missions catholiques*.

The great work undertaken by the Russian Geographical Society under the title of "Works of the Ethnographical and Statistical Expedition to South-Western Russia" is now completed. The whole work consists of seven volumes, in nine fascicules, or nearly 4,800 pages, and it contains abundant most useful information as to those countries which afford so great an interest by the variety of their population.

We notice the appearance of the following important works recently published by the Russian Geographical Society:—(1) The eighth volume of its *Memoirs* (*Zapioki*), which contains a "General Sketch of a Theory of Constant Marine Currents," by Colonel Schilling, and a "Note on the New Map of Persia," by General Stebnitzky, with the map itself, which is one of the most important acquisitions to the exact cartography of Asia during recent years.—(2) The fourth volume of the translation of Ritter's "Asia," being the description of the Altay and Sayan Mountains within the limits of the Russian Empire, with a very important appendix (far larger than the original work itself), by MM. Potanin and Semenoff, being a *résumé* of all new information acquired from 1832 to 1875.—(3) "The Kashgar Land" (*Kashgaria*), an historical and geographical sketch, of the country, of its military forces, industry, and trade, by M. Kuropatkin, with additions of General Stubendorff and M. Sreznevsky.—(4) "A Journey to the Holy Land of the Prince Radzivil-Sirotka during the Years 1582 to 1584," published and annotated by M. Hildebrandt; and (5) The two first volumes of a "Catalogue of the Library of the Geographical Society," containing books on mathematical, physical, and general geography. The importance of this catalogue will be realised by all those who know what a number of works appear in Russian on the geography of Russia and Asia, and how difficult it is to know them. We notice with pleasure that the catalogue contains detailed indexes of all papers that have appeared in the publications of the Geographical Society. An important work, being the description of M. Potanin's journey to north-western Mongolia is already in the press.

CELESTIAL PHOTOMETRY

The volume of the annals of the Harvard Observatory just issued is one of great importance to astronomical science, as the new director, Prof. Pickering, has included in it the photometric observations which have lately been carried on with so much vigour. The first chapter is devoted to a description of the forms of instruments—many of them new—which have been employed, and in this notice we shall limit ourselves to an analysis of this part of the volume.

The first instrument employed was constructed by attaching a Nicol to a double-image prism in such a way that it could turn freely around its axis. By a graduated circle and index, the angle could be measured to tenths of a degree. When two bright objects were viewed through this instrument, two images of each were formed by the double-image prism, either of which, by turning the Nicol, could be made as faint as was desirable. Whatever their relative light, the faint image of the brightest could thus always be reduced to equality with the bright image of the faint object. The true relative brightness is then deduced from the angle through which the Nicol is turned.

This form of photometer may be used without a telescope in the comparison of bright stars which are sufficiently near each other, but the loss of light is large. By Fresnel's formula for the reflection of light, each of the four surfaces of the prisms will reflect four per cent. The amount they would transmit, were there no other losses, would therefore be $(\cdot 96)^4 = \cdot 849$. This supposes that the faces of the Nicol are perpendicular to its axis. If made of the usual form, the loss would be still greater. The unavoidable defects of the surface, dust, absorption, and the reflection at the surface of the balsam cementing the prism, reduce still further the transmitted light. About ·80 will remain under favourable circumstances. Since the prism forms two equal images, only one half or ·40 can pass into each, and when the two images are reduced to equality, their brightness will be only ·20 or ·40 of that of the fainter object. For any but the brightest of the heavenly bodies, it is accordingly necessary to increase the light by means of a telescope.

The following general remarks occur on this form of instrument.

"Since the relative positions of the Nicol and double-image prism are unimportant, either might be placed in front of the object-glass, between the object-glass and the field-lens, between the field-lens and eye-lens, or between the eye-lens and the eye. Unless the double-image prism is placed in front of the object-glass, two images of the latter will, in general, be formed, giving two emergent pencils, both of which must pass without loss into the eye. There is danger that on moving the eye one or other of these pencils will be partially cut off, thus reducing the brightness of one of the objects. If the two images to be compared are brought very near together, this is less likely to occur. On the other hand, at least one of the images of a double-image prism is not achromatic; and, if the prism is placed in front of the object-glass, the colour becomes very marked. In this case, also, it becomes difficult to obtain a prism having such flat surfaces that the images will not be distorted, since any irregularities are magnified by the full power of the telescope. If the two images are separated by a distance *d*, any two stars at about this interval may be brought together, so that any star may be compared with all those on the circumference of a circle having a radius *d*. With a large prism in which *d* equalled about 3°, an attempt was made to compare β and ρ *Persei* and β and γ *Lyræ* by placing the prism in front of the objective of a telescope having an aperture of about 10 cms. A direct measure of the variations in brightness of the above-named variable stars might thus be obtained. This plan was abandoned, owing to the colour of the images.

"There is one other position of the prism, that where the eye-piece forms its image of the objective, in which the emergent pencil will remain undivided. This is, however, the exact point at which the eye should be placed; and, moreover, the

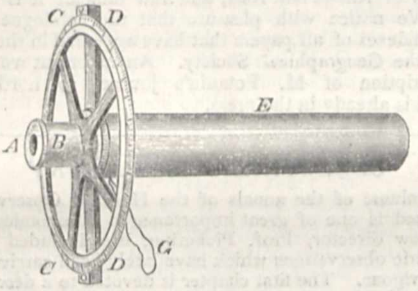


FIG. 1.

interval between the images cannot, in this case, be altered. Good results were obtained by placing the prism a little nearer the eye-piece, as in the first of the instruments described below. The advantage of placing the prism between the eye-lens and field-lens is that it is less likely to reduce the field of view. As this plan is open to the double objection of dividing the emergent pencil and keeping the images always at the same distance apart, it has not been employed in the following observations.

"The fourth position for the prism is between the field-lens and objective. It then separates the emergent pencils by an amount increasing with its distance from the objective, but, on the other hand, the interval between the images is proportional to its distance from the focus. Whatever, therefore, is the interval between the two stars, within certain limits, their images may always be made to coincide by first turning the prism and

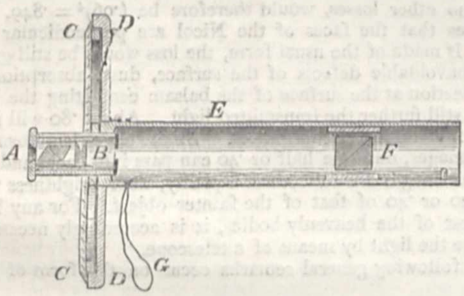


FIG. 2.

then sliding it along the axis of the telescope to the proper distance from the focus. A prism may therefore be used, in which the separation is small, and thus the two images of the objective may be rendered nearly coincident.

"The position of Nicol is comparatively unimportant. Since it must turn without moving the double-image prism, it is more convenient to place it between the latter and the eye. It was, accordingly, sometimes placed between the eye-lens and the eye, and sometimes between the field-lens and eye-lens."

We now come to the instruments.

The first observations were made with an eye-piece having a Nicol between its two lenses and with the double-image prism between this eye-lens and the eye. The observations made with this apparatus are regarded as preliminary; a second photometer was constructed, in which the Nicol and double-image prism were both placed in front of the eye-lens, the Nicol being next the eye. One marked advantage of this instrument, was that the circle instead of the index, turned with the Nicol. The labour of reading was thus much reduced. The Nicol was also replaced by a double-image prism, with the advantage that the field of view was less obstructed. With this form, however, the great number of images formed by successive reflections, when a bright object was observed, rendered it sometimes difficult to determine which should be compared.

A much simpler arrangement was used later. It consisted of two concentric tubes, one carrying a graduated circle, the other two indices. In the first of these tubes, a double-image prism was inserted; the other, which was held next the eye, carried a Nicol. This photometer was used without a telescope

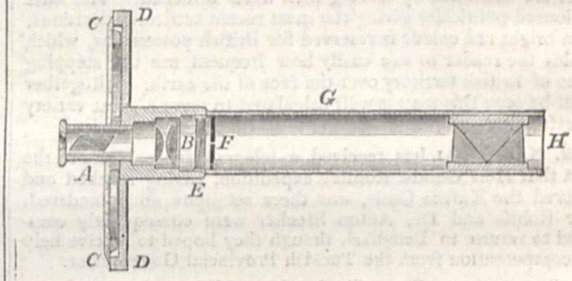


FIG. 3 (Scale ½).

to compare the relative brightness of Saturn and Mars, and Jupiter and Venus. A tube was attached to this photometer, so that the light should always pass nearly normally through the prisms. When the objects were sufficiently bright, and within a few degrees of one another, good results were thus obtained, but the colour of the images, and their want of symmetry, was a serious objection when a great difference in light was to be measured.

After an experience of some months with these instruments, certain improvements suggested themselves, and still another photometer was constructed, represented in perspective in Fig. 1, and in section, on a scale of one-fifth, in Fig. 2. In both figures, B represents the eye-piece, in front of which is

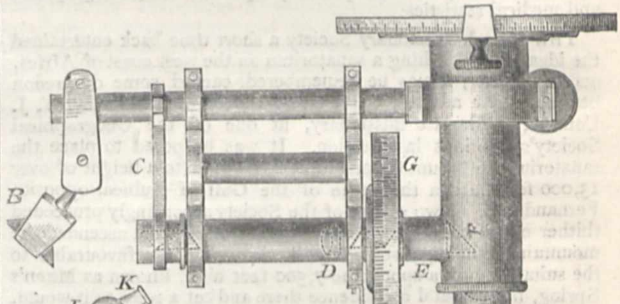


FIG. 4 (Scale ½).

inserted a Nicol, A. A circle, divided into degrees, is attached, and turns with the eye-piece. The indices D D are fastened to the tube E, which slides into the telescopes. F is a rochon prism, which was used instead of a double-image prism of spar. As it consisted of quartz, the separation of the images amounted to somewhat less than 1°, so that the emergent pencils overlapped each other by nearly three quarters of the diameter of each. The apparatus had, moreover, the great advantage that the images were precisely alike and nearly achromatic. The prism was placed in a tube, which could be drawn towards or from the eye-piece by a cord G. Attaching this photometer to a telescope, and directing it towards a star, the latter appeared double; and the interval between the components might be altered at will.

These photometers could only be used for comparing objects very near together, as double stars, or satellites. For greater intervals, another device was tried. Two achromatic prisms of small angle were placed in front of the telescope, so as to cover the central portion of its object-glass. Two images of any object would thus be formed, separated by an interval dependent on the angle of the prisms and on their relative positions. By turning one or both of the prisms, the directions of the two images may be altered at will, and their distance varied between the sum and the difference of the angular deviation of the prisms.

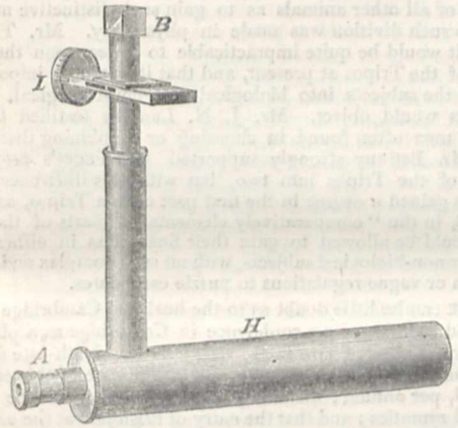


FIG 5.

After bringing the images near together, they could be compared by one of the photometers described above. This method was tried with two circular prisms, having a diameter of 4·4 cms., and producing a deviation of about 1°·3. A telescope was used having an aperture of 10 cms. The light of any objects nearer than 2°·6 could be measured with this instrument. The constant, or proportion of the light transmitted by the prisms, was easily determined by comparing, by the photometer, the two images of the same object. This instrument, like those previously described, has the great advantage that both objects are seen under the same magnifying power, and therefore closely resemble

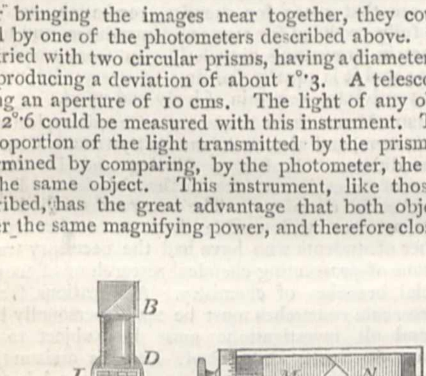


FIG. 6.

each other, even when the condition of the air is not good. This plan cannot be used for large intervals, since, if the angles of the prisms are large, the images will be coloured by the secondary spectrum, and it would also be difficult to find the objects. With a large telescope, the prisms could not be reached easily by the observer, and the large diameter required would be an objection to their use.

The idea suggested itself to Prof. Pickering, that such photometers might be used to compare the colours of the components of double stars, by measuring *the relative light of different portions of their spectra*. A combined spectroscope and photometer, shown in Fig 3, was devised. A is a Nicol, placed in front of the eye-piece B. The graduated circle C C is attached directly to the tube carrying the Nicol; and the indices D D are fastened to the tube G, which slides into the telescope. H is a direct-vision prism, by which the images of the stars are converted into linear spectra. F is a diaphragm placed at the focus, and having a slit in it ·02 cms. broad, parallel to the edges of the prism. It is, therefore, perpendicular to the spectra, and permits a short portion of each to pass through. These appear as two stars, of a colour which may be varied with the position of the objects observed, as regards the axis of the telescope. Their relative light was measured by forming two images of each, by a plate of Iceland spar, E, which was used instead of a double-image prism, since the rays were not parallel. The light was then measured by turning the Nicol.

All of the photometers described above are open to the objection that the loss of light is very great. Under the most favourable circumstances only ·20 to ·40 of the light is used; so that, with the large telescope of aperture 38 cms., faint objects appear no brighter than with a telescope having an aperture of 18 to 24 cms., with a common eye-piece. To remedy this objection which was greatly felt during the observations of the satellites of Mars, a class of photometers of wholly different form was tried.

In these the image of some bright object, assumed as a standard, is reflected into the field of the telescope, and its light reduced by a known amount, until it is no brighter than the object to be measured. An unobstructed view of the latter is obtained meanwhile, with an eye-piece of the usual form. The first of these instruments is represented in Fig. 4.

The image of the faint object formed by the telescope is viewed by the eye-piece A. The light of the bright star taken as a standard, passes outside the telescope, and falls upon the prism B, by which it is reflected through the objective D of a small auxiliary telescope, and falling on the prism F, is brought into the field of view. The faint object is thus seen in one half of the field with the full aperture of the telescope; while the bright standard appears in the other half of the field, its image being formed by the small telescope. C and E are two Nicols, of which E may be rotated, and the light passing through it reduced at will. G G is a graduated circle, attached to the tube carrying D and E, and measuring the reduction of the light by an index H, which is fixed. The whole photometer may be turned around the axis of the large telescope, the tube carrying the prism enables the latter to rotate around the axis of the auxiliary telescope, and, finally the prism may be tipped around an axis parallel to its edges. Either two of these motions enable the observer to bring any object into the field of view of the small telescope. Practically, the second and third motions were used for the purpose. The first of these movements was reserved almost exclusively for the purpose of placing the prism so that it would conceal the bright star or planet with which the faint object was to be compared, when their distance apart was small. Otherwise, its light as seen in the large telescope, would be so intense as to interfere with the proper estimate of the light of the faint object. I is a lamp, by which the half of the field covered by the prism F may be illuminated, so as to render it as bright as the other half of the field. A piece of blue glass, K, served to vary the colour of the light.

Great difficulty was experienced in obtaining good images of bright stars with the small telescope, on account of the Nicols used. Since the rays passing through E are convergent, aberration is caused by the obliquity of its faces, even if they are plane and parallel. Hence the Nicols were removed, and a new form tried. The lenses of a double-image micrometer being taken out, two V-shaped pieces of brass were attached to the slides carrying the divided lens. A square hole, or "cat's eye," was thus formed, whose dimensions could be altered at will, by turning the micrometer screw. This arrangement is shown in M N, Fig. 6. Placing it near the objective D, Fig. 4, the light was varied by changing the aperture of the small telescope. All these instruments, however, were heavy, difficult to adjust, and not easily removed and replaced. These defects were remedied by still another form, represented in perspective in Fig. 5, and in section, on a scale of one-fifth, in Fig. 6. The same letters are used as in Fig. 4, for the corresponding parts. The faint object is viewed with the eye-piece A, while the light of the bright object, passing outside of the telescope, is reflected by the prism B into the object-glass D, whose aperture is varied by the screw I, which moves the plates M N. Finally, the prism F throws the light into the field of A. The whole is attached to the tube H, which slides into the end of the telescope. This photometer is light, can be easily removed, and by a suitable adapter may be attached to any telescope. As it forms a single piece, the adjustments are little liable to be disturbed.

In some observations, especially during twilight or moonlight, errors were apprehended from the comparative darkness of that half of the field covered by the prism F. This prism was replaced in other forms therefore by a piece of parallel glass. They were then called photometers E′ and J. The reflected stars they formed were much fainter, and double, one image being produced by each surface of the glass. Still these instruments had the advantage that the field was unobstructed, and the star to be measured might be placed in any desired position, as regards the standard.

The latter class of photometers can be used only in the measurement of faint stars. If the image of the object seen in the large telescope is brighter than that formed by the auxiliary telescope, no setting of the Nicols or micrometer screw will render them equal. This difficulty was obviated by using the photometer shown in Fig. 4, removing the Nicols, and replacing its eye-piece by the concentric tubes referred to in an early part of this analysis. The images of the same object, seen in the large and small telescope, were first compared, and the constant thus found was used in reducing the observations of other objects. The advantages of this photometer are that stars of greatly different brightness and in different parts of the sky may be compared; but the loss of light is great, and the images are seen under different magnifying powers.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The Board of Natural Science Studies have recommended a new set of regulations for the Natural Sciences Tripos, to take effect as regards the first part of the examination, in the Easter Term of 1881, and as regards the second part in Easter Term of 1882. In effect it is intended to provide for a class list in general natural science honours in June each year, founded on aggregate knowledge shown by candidates in the first part of the examination, provided no credit is given in a subject unless the candidate has shown a competent knowledge of that subject. Each of the three classes is to be arranged in alphabetical order. The general arrangement of subjects and practical work has already been settled, but the details will no doubt invite attention. The working of Regulation 6 is rather curious. "In the first part of the examination there shall be a practical examination, either written or *vivâ voce*, or both, in such subjects as the Board of Natural Science Studies shall from time to time determine, provided that in all those subjects in which there is no such practical examination, one or more of the questions in the printed papers refer to objects exhibited at the examination." Regulation 7 states that there is to be a practical examination either written or *vivâ voce*, or both, in each of the eight subjects of examination in the second part. Regulation 14 proposes that, in arranging the class-list for the second part of the examination, the examiners shall have regard to general knowledge and ability as well as to special proficiency in one or more subjects. No candidate shall obtain a first-class for proficiency in one subject unless he show a competent knowledge of some cognate subject. When Human Anatomy is taken as the principal subject, either Zoology and Comparative Anatomy, or Physiology, be taken as a necessary cognate subject. Regulation 15 includes the following:—In each case of giving a first class in the second part of the examination, the examiners shall specify the subjects for which the candidate is so placed, or the reason for specially distinguishing him.—A discussion in the Arts School on the proposed regulations for the Natural Sciences Tripos (on October 31), was opened by Mr. Sedley Taylor expressing great doubts about the desirability of giving such a prominent place to human anatomy in an honours examination. He read to those present the opinions of three eminent physiologists and anatomists specially obtained by himself on this point, and they were, on the whole, against the proposed regulation as unnecessary, if human anatomy were to be taught in the only way in which it could fairly enter into the Tripos, for its general and not its professional value, while usually the memory work involved was enormous, and such as to be of quite technical character. Dr. Humphry strongly supported the regulations and the distribution of subjects, as a method of aiding in preserving a scientific study of human anatomy. Dr. Paget dissented strongly from this view, not as a means of discouraging the study of anatomy, but to lessen the strain of constant change by questions which went to the root of the matter. He believed no sufficient settlement could be expected unless or until the Tripos was divided into two—biological and non-biological; it was unwieldy and unmanageable in its present state. Surely it was not impossible to frame some division of subjects which might secure this and be found workable. Mr. Balfour did not agree with the way in which human anatomy was regarded as so far apart from the anatomy of all other animals as to gain such distinctive marks, while no such division was made in physiology. Mr. Trotter thought it would be quite impracticable to enter upon the discussion of the Tripos at present, and that it would be impossible to divide the subjects into biological and non-biological. The geologists would object. Mr. J. N. Langley testified to the difficulty men often found in choosing or combining their subjects. Mr. Bettany strongly supported Dr. Paget's projected division of the Tripos into two, but with this difference, that men who gained a degree in the first part of the Tripos, as now proposed, in the "comparatively elementary" parts of the subjects, should be allowed to gain their final class in either biological or non-biological subjects, without such complex and often uncertain or vague regulations to puzzle candidates.

THERE can be little doubt as to the health of Cambridge being good, and the increasing confidence in Cambridge as a place of education, in view of two facts, viz., that the death-rate during the Michaelmas quarter has been only at the rate of thirteen per thousand, per annum; including only six deaths from the seven principal zymotics; and that the entry of freshmen at the colleges this year is the largest ever known, having increased by at least one hundred. It is the more incumbent on the university or the colleges, to see that space for exercise, recreation, study, and sleeping are fully provided for every undergraduate, and to take an active part in preventing disorderly men from remaining to vitiate others; and it is equally the duty of every wise man not to tempt our youth into overstrain of body and mind.

MR. PATTISON MUIR, Caius Prælector in Chemistry, lectures on the Metals this term, and also on Advanced Systematic Chemistry to Tripos candidates. Professors Liveing and Dewar have issued a notice of great importance to those desirous of prosecuting researches in chemistry. The new rooms added to the Chemical Department will enable them to accommodate a limited number of students who have had the necessary training and are desirous of prosecuting chemical research or of acquiring skill in special branches of chemistry. Applications for permission to prosecute researches must be made personally to the Professors, and all investigations must be subject to their approval. Mr. A. Scott, B.A., Prof. Dewar's assistant, will have the general superintendence of this part of the laboratory.

A COURSE of practical instruction in Experimental Physics will be given in the Cavendish Laboratory during this term. The course will be adapted to the requirements of beginners, and demonstrations will be given daily at times to be arranged with the members of the class. Thus again one of the most necessary classes is to be provided, but we trust Mr. Garnett's energies in this department will not be overtaxed.

OXFORD.—In a congregation to be held on November 18, the amendments to the proposed statute respecting degrees in Natural Science will be considered. As the proposed statute now stands, scholars in the Faculty of Natural Science may offer for Responsions Greek and Latin, or Greek or Latin with either French or German, and shall also be examined in arithmetic, the elements of plane geometry and algebra up the binomial theorem. An amendment has been proposed by Prof. Rolleston to substitute the elements of deductive logic for algebra beyond proportion. In moderations (first public examination), Prof. Rolleston proposes to insert deductive and inductive logic as an alternative for algebra. Candidates will be obliged to offer either Greek or Latin, with either French or German, and will be examined in the theory of logarithms, Euclid, trigonometry as far as the solution of plane triangles, and elementary mechanics. The council have proposed amendments abolishing those clauses granting the rights of Masters of Arts to Masters of Natural Science, since counsel's opinion has given it to be beyond the power of the University to grant such privileges to a new faculty. The council will accordingly propose a decree authorising the Vice-Chancellor to take whatever steps may be necessary to obtain the power of conferring on Masters in Natural Science the rights and privileges at present enjoyed by Masters of Arts.

The statute providing that there shall be two examiners in each of the three branches of the natural science school will come into operation this term. The three new examiners will be Dr. Odling in Chemistry, Prof. Ray Lankester in Biology, and Mr. W. N. Stocker, Brasenose, in Physics.

Dr. Acland, Regius Professor of Medicine, will give a public lecture at the Museum, November 20, on the new hospital at Baltimore, U.S., and its relation to the medical studies at the Johns Hopkins University, and to general medical education.

Mr. C. J. Baker, of Manchester Grammar School, has been elected to the Physical Postmastership at Merton College.

THE Board of Trinity College, Dublin, have elected Dr. Alexander Macalister to the Professorship of Anatomy, and Chirurgery, in Dublin University, vacant owing to the resignation of Dr. B. McDowel. Prof. Macalister still retains his Professorship of Comparative Anatomy, but resigns the Professorship of Zoology and the Directorship of the Zoological Museum. The election to the former of these posts we observe is fixed for an early day in this month; the nominators are the members of the academic council of the University of Dublin, with a veto on the person nominated by the board. The election to the Directorship of the museum is in the hands of the board, and to this the person elected has always been the professor of zoology. The yearly emolument from both posts is between 300*l* and 400*l*. a year.

SCIENTIFIC SERIALS

Annalen der Physik und Chemie, No. 9.—Questions in molecular physics figure largely in this number. Herr v. Wroblewski inquires into the nature of absorption of gases, by a kinematical method, inferring from the phenomena of motion of gases diffusing in absorbent substances, the condition in which they exist in these. The phenomena in caoutchouc are studied, and the author concludes, *inter alia*, that the absorption of protoxide of nitrogen, carbonic acid, and hydrogen by caoutchouc is a purely physical process, and the gases retain, after absorption, their gaseous state and all characteristic properties. The constant of diffusion of a gas depends only on physical properties, and chiefly its specific gravity, being approximately inversely proportional to the square root of this; but the specifically lighter gases show greater constants than this relation expresses. The constant for protoxide of nitrogen and carbonic acid increases with increase of temperature, and at 10° C. is fifty times smaller than that for carbonic acid in water. A caoutchouc membrane is to be conceived as a porous plate endowed with gas-condensing and rarefying powers (the gas moving through the pores).—M. Chappuis investigates the condensation of gases on a glass surface by a similar method to Magnus's, viz., measuring the expansion between two exactly known temperatures, of a certain volume of gas at constant pressure in contact with a large glass surface, and inferring the original volume of the gas. The numerical results for hydrogen, air, carbonic acid, sulphurous acid, and ammonia, from 0° to 100° and 180°, are given, and utilised in determining the absolute coefficient of expansion at constant pressure (a slight correction of the former determinations being necessitated by the phenomenon in question). Magnus's statement that at 100° there is no condensed gas layer on a glass surface is shown to be incorrect in the case of ammonia.—A paper by Herr Schleiermacher treats of the quantity of liquid condensed on a moistened body. The author rejects Wilhelmy's numerical values for the condensation, and considers that, in determining the specific gravity of a liquid, if one be content with an accuracy of 0·002 per cent., the influence of condensation may be neglected; in general the coefficients of condensation would be, at the most, of the order of $0{\cdot}00001 \frac{\text{g}}{\text{Sq. ctm.}}$—The specific heat of water is anew determined by Herr Heinrichsen, who arrives at the number 1·071 (for 100°); this stands about midway between Regnault's result, 1·013, and Jamin's, 1·122. (Stamo got 1·125, and Münchhausen 1·030.)—Herr Koch finds that the oxygen-polarisation of platinum and palladium increases the friction of these metals to a glass surface coated with water or dilute sulphuric acid.—Mr. B. O. Peirce, jun., shows from experiments how greatly the electromotive force of gas elements depends on the nature of the electrolyte.—Herr Edlund, replying to a criticism by Herr Dorn, gives experimental evidence that the electromotive force in passage of liquids through tubes depends directly on the velocity, and not on the pressure; also that it is inversely proportional to the cross-section; and explains the facts observed by the unitarian theory.—Herr Fenkner expounds some laws of transverse vibrations of metallic cylinders open at one end.—Remaining papers:—Researches on anomalous dispersion of light, by Herr Sieben.—Researches on the height of the atmosphere, &c. (continued), by Herr Ritter. —On the electromotive force of the Grove element in units of Siemens and Weber, by Herr Riecke.

THE *Journal of the Royal Microscopical Society*, vol. ii. No. 6, October, contains the *Transactions* of the Society.—On a new species of Cothurnia, by John Davis; with Plate 20. Cothurnia is a genus of stalked infusoria very closely allied indeed to Vaginicola. Mr. Davis's new form is apparently very correctly referred to it; but if so, his species is not a rotifer, and, we presume, does not possess a mastax. The infusorian is described as much smaller than its lorica, and is so figured when contracted; this is not characteristic of a rotifer.—On some causes of Brownian movements, by Dr. W. Ord. Observations suggested by the study of *Amphipleura pellucida* mounted in Canada balsam, by lamp-light and sun-light, with various objectives, by Col. Woodward.—On Abbe's experiment on *Pleurosigma angulatum*, by Col. Woodward.—On new species and varieties of diatoms from the Caspian Sea, by Dr. A. Grunow; translated, with additional notes, by F. Kitton; with Plate 21.—The Record of current researches relating to invertebrata, cryptogamia, and microscopy. This record forms a most valuable portion of this journal. It occupies over 100 pages of this number, and, as far as one can judge, the notices give a very fair epitome of the papers quoted. The attempt to make this record a complete one of the invertebrates and of cryptogams is praiseworthy, but it seems to us that our yearly zoological and botanical records already do this in a fairly perfect way. Would it not be better that this bi-monthly record should confine itself to those papers of special interest to the microscopist. In this record references to papers of the type of Fischer on *Voluta musica*, Norman on Solenopus, or Pfeffer on Philippine pteropods, might be omitted. Only those who have worked at compiling bibliography know the great labour and skill required to keep up such a record; and certainly the editor of this journal deserves the special thanks of all workers with the microscope.

THE *Gazetta Chimica* (fasc. vi. and vii.) contains the following papers:—On the chlorides and oxychlorides of tungsten, by U. Schiff.—On a method of preparing economically the bibasic citrate of quinine, by F. Dotto-Scribani.—Researches on *Satureja juliana*, by P. Spica.—Chemical researches on the salts obtained from the mother liquors of the salt works of Volterra, by A. Funaro.—Chemical analysis of a Chilian chrysocolla, by N. Pellegrini.—On a singular decomposition of the chlorhydrate of phenyl-ethyl-amine, by M. Fileti and A. Piccini.—On some neutral ammonia salts (citrate, phosphate, photosantonate), by F. Sestini.—New experiments on resinous substances, by G. L. Ciamician.—On the isomeric nitrosalicylic acids, by U. Schiff and F. Masino.—On the pretended artificial tannic acid, by P. Freda.—On piperidine, by R. Schiff.—On the action of cyanide of potash on the ammoniacal derivatives of chloral, by R. Schiff and S. Speciale.—On the crystalline forms of anglesite from Sardinia, by Q. Sella.—On the forms of crystallisation of some substances belonging to the aromatic series, by R. Panebianco.—On lithofellic acid and some lithofellates, by G. Roster.—Chemico-mineralogical researches on the lavas of the volcanoes of the Ernici in the Valle del Sacco (Rome), by S. Speciale.—On the discovery of nitric acid in the presence of nitrous acid, by A. Piccini.

THE *Rivista Scientifico Industriale* (Nos. 17 and 18).—From these numbers we note the following papers:—On a new method for determining the distribution of magnetism in magnets, by Prof. G. J. Agostini.—On the electromotive forces developed by saline solutions of different degrees by concentration with the metals which form their base, by A. Eccher Dall' Eco.—On the temperature of the voltaic arc and of the positive and negative polar extremities of the carbons during the production of the electric light, by Prof. Rossetti.—On the decomposition of chlorhydrate of ethyl amine by heat, by M. Fileti and A. Piccini. —On the preservation of dragon flies with fading colours, by Prof. Pietro Stefanelli.—On a new hydrometer for measuring the water supplied to steam-boilers, and called "Isaghidrometro" by its inventor, Sig. Massarotti.—On the work which can be performed by the beams of certain aquatic motors, by Cesare

Modigliano.—On a palæontological discovery made at Montegazzo in Fellina (province of Reggio-Emilia), by Prof. A. Ferreti.—On some recent communications made to the Paris Chemical Society, by the Editor.—On the filling of a barometer tube in vacuo, by Prof. Damiano Macaluso.

THE *Archives des Sciences physiques et naturelles* (September, Geneva) contain the following papers of note:—Review of the principal publications on physiological botany during 1878, by M. Marc Micheli.—On xylic acid, its preparation and compounds derived from the same, by MM. E. Ador and Fr. Meier.—Note on the last report of the Council of the Royal Astronomical Society (London), by Prof. Gautier.—Analysis of some recent works relating to the topography and the constitution of the moon, by M. Rapin.—Account of the sixty-first meeting of the Swiss Naturalists' Association, on Aug. 12–14, 1878. The remaining contents of the number consist of mere extracts from papers published in other serials and relate all to chemistry.

La Natura (vol. iii., Nos. 16 and 17) contains the following papers of interest:—On the intensity of electric currents and of extra-currents in the telephone, by G. Farraris.—On the correction of mercury thermometers, by C. Ferrari.—Observations made during the earthquake of August 9 last, by A. Serpieri.—On two new meteorological works, by C. Ferrari.

SOCIETIES AND ACADEMIES

LONDON

Mineralogical Society of Great Britain and Ireland, October 21.—Dr. M. Forster-Heddle, president, in the chair.—The following papers were read:—On the mineralogy and geognosy of the Orkney Islands, by the president.—On a probably dimorphous form of tin, by Dr. C. O. Trechmann.—On some Cornish tin-stones and tin-capels, by J. H. Collins, F.G.S.—Experiments on the elasticity of minerals, by John Milne.—On a peculiar pasty form of silica from Leadhills, Scotland, by Andrew French, F.C.S.

PARIS

Academy of Sciences, October 27.—M. Daubrée in the chair.—The following papers were read:—Notice on the life and scientific works of M. Dortet de Tessan, by Admiral Paris.—On the galvanic oxidation of gold, by M. Berthelot. This refers to Grotthuss's observation of the dissolving of gold-wire when used as positive pole in sulphuric acid traversed by a current. The attack is not due to formation of persulphuric acid, but solely to the influence of the current and contact of the electrode with the electrolysed liquid.—Decomposition of selenhydric acid by mercury, by M. Berthelot. He observed such decomposition when the substances had been in contact with each other a few years.—Note on the development of railways in Brazil, by Gen. Morin. Two maps from the Emperor were shown. The total length of railway in operation in the provinces of Rio de Janeiro, St. Paul, and Minas Geraës, is 2,882 km.; in construction, 1,751 km.; total, 4,633 km. From 1,000 km. to 1,200 km. of the working lines have a broad gauge of 1·60 m.; the rest, for local traffic, a gauge of 1 m. The mountain chain near the sea in Rio de Janeiro presented great difficulties, but beyond, the railways lie in long and fertile valleys.—Critical reflections on experiments concerning human heat, by M. Hirn.—On the gymnastics of M. Zander of Stockholm, by M. Norström. This is a system of mechanical and passive gymnastics, machinery worked by steam being used to move the limbs of the subject in various ways (the force being suitably proportioned). M. Larrey remarked on the complicated and expensive nature of the apparatus, and desired scientific data as to the effects obtained.—Result of researches made with a view to find the origin of estival reinvasions of phylloxera, by M. Faucon. The principal cause he considers to be carriage by the wind (inferred from the result of fixing a sheet of oiled white paper on a board at the top of a post facing the wind). Other causes are passage of the insect on the surface of the ground, and the presence of eggs.—On the appearance of mildew or false American oïdium in the vineyards of Italy, by M. Pirotta.—Determination of longitudes, latitudes, and azimuths in Algeria, by M. Perrier. He shows that the probable error of each definitive result is about one-tenth of a second of an arc.—Specific heats and points of fusion of different refractory metals, by M. Violle. The specific heat of iridium grows regularly with the temperature, and the formula gives 1950° (of the air-thermometer) as the point of fusion. The specific heat of gold hardly varies up to 600°, then gradually increases towards the point of fusion, 1035°. Other points of fusion: silver, 954°; copper, 1032°, palladium, 1500°, platinum, 1775°.—Chloride of lime battery, by M. Niaudet. The positive electrode is a zinc plate in a solution of chloride of sodium. The negative, one of carbon surrounded by fragments of carbon and chloride of lime in a porous vessel. All the combinations produced are soluble, and the battery remains an indefinite time at rest without being used up. The electromotive force at first is over 1·6 volt.—On the combinations of phosphuretted hydrogen with hydracids, and on their heat of formation, by M. Ogier.—On erbine, by M. Clève. He recognises M. Soret's priority, and the identity of the substances he himself called *holmium*, with M. Soret's X.—Complementary note on commercial trimethylamine, by MM. Duvillier and Bursine.—On ordinary cellulose, by M. Franchimont. This refers partly to dehydration of cellulose with sulphuric acid (chloride of zinc did not decompose cellulose).—On glucose, by M. Franchimont.—On the transmissibility of human rabies to the rabbit, by M. Raymond. Two rabbits were inoculated with blood and saliva (respectively) from a hydrophobic person. That inoculated with saliva showed signs of rabies four days after, and soon died. Pieces of its salivary glands (got thirty-six hours after death) were introduced into two other rabbits, who also died (paralysed), but without passing through a violent stage.—Researches on Daltonism, by MM. Macé and Nicati. They aimed at comparative measures of the quantities of light perceived in different parts of the spectrum by the Daltonian and the normal eye. Curves were got corresponding to the three varieties of Daltonian eye. The descent of the curve in the green the authors think they have been the first to prove certainly. No simple relation between visual activity and intensity of light was ascertained.—On the origin of the toxical properties of the Indians' curare, by M. Du Lacerda. None of the vegetable or animal juices often added by the Indians to the product of Strychnos have the effects of curare, and *Strychnos castelneæ*, also, *S. triplinervia*, are found to give curaric effects fully.—Experimental researches on human heat during rest in bed, by M. Bonnat. In all seasons the minimum of the body-temperature (observed in the rectum) is between midnight and 3 A.M. At Nice, in winter, the minimum is rarely under 36°·3; in summer, 36°·4 or 36°·5. From 3 A.M. the temperature rises till 9 A.M. (becoming, *e.g.*, 36°·9 in winter). The maximum is between 2 P.M. and 4 P.M., and from 9 P.M. the temperature slowly falls to the minimum. From 9 A.M. to 9 P.M. in winter the variations do not exceed three-tenths or four-tenths of a degree C.; in summer they may reach six-tenths.

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