COMPARISON OF THE SPECTRA OF THE LIMB AND OF THE CENTRE OF THE SUN*

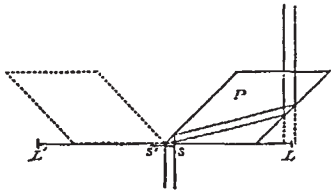
A COMPARISON of the spectrum of the edge of the sun with that of its centre is of great theoretical interest; but any comparison other than by direct juxtaposition must be very unsatisfactory, and the more so as the differences are less. In order to obtain spectra of two different portions of the sun side by side, where the slightest variations may be detected, I have constructed a small prism with four polished sides, its bases being parallelograms. This is so placed that one face rests upon the slit plate of the telespectroscope, and has its acute edge perpendicular to the slit at its middle point. The instrument may then be directed so that the image of the sun falls with its centre on the uncovered portion of the slit, while the light which forms the edge of the sun, falling perpendicularly upon the first surface of the prism, suffers two interior total reflections and a displacement depending upon the form of the prism. A glance at the figure, in which $s\,s'$ is the slit, L L′ the diameter of the sun's image, and P the prism, shows that no light from the covered part of the slit will reach the collimating lens except that which has been reflected from the two sides of the prism. The relation of the acute angle (v) and the distance between the reflecting sides (t) to the focal length of the great telescope (F) and the width of the spectrum (a) is given by the formula,

$$2t \sin v = F \tan 16' - a.$$

The sides of the prism not fixed by the equation admit of considerable latitude, but should be made to approach the lower limit in order that the planes of the direct and transmitted images may be as little separated as possible. Of course t and v should be so proportioned that the reflections may be total.

The instruments with which the following observations have been made are those belonging to the observatory of the Sheffield (U.S.) Scientific School, consisting of an equatorial telescope of 9 in. aperture, and 118 in. focal length, by Clark, and a spectroscope of Young's form by the same maker. The spectroscope has a dispersive power of 12 prisms of 60°. In most of these observations an eye-piece of high power has been adapted to it, which gives a separation of the D lines equal to 64 minutes nearly. In the small prism placed before the slit, a is equal to 04 in., a quarter of the length of the slit.

When the instrument is properly directed and in adjustment, we see a very narrow black line dividing the spectrum longitudinally into two parts of widely different intensity; the fainter,



belonging to the limb of the sun, is marked on its edge by the bright chromosphere lines. Upon comparing these two spectra, certain differences are recognised besides that of intensity, by far the most marked of which are exhibited by the lines b_1 and b_2, which become sharper and less hazy near the limb. The line b_3 possesses the same characteristic, but to a less degree; C and F also become sharper in the same region. Excepting these and the D lines it requires very close examination to detect any variation. There is, however, a line in the red at 768·1 of Kirchhoff's scale which is strongly marked near the centre of the sun's disc, but disappears entirely, to my power at least, within 16″ to 20″ from the limb. Two other lines below F, at 1828·6 and 1830·9 of the same scale, exhibit nearly complementary phenomena, *i.e.*, they are strongly marked near the edge, but much fainter at the centre. These latter lines also become greatly strengthened over the penumbræ of spots. The line 768·1 is not thus affected. These are all the differences which I have invariably seen in repeated examinations since February 17.

Others have, however, been suspected. Certain lines, which are strengthened in a region of spots like those above mentioned, appear to be strengthened also near the edge, but do not undergo so marked a change. It is obvious that the differences should be most pronounced in the clearest sky, and such is the case. The closest examination has extended only from B to a short distance above F, as the plate glass of which the small prism is made has a decided yellow tint and absorbs the blue rays strongly.

Since the light from the border of the sun undergoes a general absorption, which reduces its intensity to much less than one-fourth that at the centre, according to Secchi's measurements, and yet the spectroscopic character is changed so slightly, it is impossible for me to escape the conviction that the seat of the selective absorption, which produces the Fraunhofer lines, is below the envelope which exerts the general absorption. But the phenomena of the faculæ prove not only that this envelope rests upon the photosphere, but also that it is very thin. The origin of the Fraunhofer lines, then, must be in the photosphere itself, which is in accordance with Lockyer's views.

Any effects which the chromosphere might produce, we would anticipate finding most evident in the lines of those gases which are readily detected there. A reference to the observations shows at once a compliance with this anticipation in the lines of hydrogen, magnesium, and sodium. The line 768·1 is not less strikingly in concordance, if it be regarded as 768·?* (the ? indicates doubt as to the tenths of the scale, and * absence of a corresponding black line) of Young's Catalogue of Chromosphere Lines. The lines 1828·6 and 1830·9, with others of the same class, probably have their origin in the medium which exerts the general absorption, and thus are allied to our telluric lines. It also seems probable that the chromosphere is too transparent to reverse many of its lines. That this is the case in the helium lines is tolerably certain.

In the apparatus described, two similar prisms were also placed over the slit in a symmetrical position. The spectra of two opposite edges of the sun were thus brought together, and the change in refrangibility due to the sun's rotation was very clearly shown.

CHAS H. HASTINGS

Newhaven, April 3

* Made at the Sheffield (U.S.) Scientific School. Communicated by Prof. Newton.

THE "INSTINCT" QUESTION

FROM the many additional communications we have received on this subject, we make the following selection.

With regard to a sense of direction, Mr. George C. Merrill, of Topeka, Kansas, writes as follows:—

I have learned from the hunters and guides who spend their lives on the plains and mountains west of us, that no matter how far or with what turns they may have been led in chasing the bison or other game, they on their return to camp always take a straight line. In explanation they say that unconsciously to themselves they have kept all the turns in their mind.

Mr. C. Bygrave Wharton, of Bushey, Herts, writes:—

As a left-handed and left-legged man who has more than once been lost in the bush in New South Wales, my experience may possibly be of interest to Mr. George Darwin and others. Invariably I unintentionally bore to the left; and once, after wandering for about six hours, just as I was giving myself up for lost, I discovered that I was within a hundred yards of the place from which I had started having performed a large circle to the left. It will thus be seen that though my left leg and arm are the stronger, there is always a tendency to walk in a circle to the left.

Mr. William Earley, of the Gardens, Valentines, sends the following interesting observations on the habits of wild rabbits:—

As is well known, the doe rabbit does not produce her young in any ordinary rabbit warren, or "run," but invariably selects a quiet out-of-the-way situation wherein to form a nursery for them. Now the reason for this peculiar practice has always been attributed to the fact that they leave their legitimate homes at this all-important period, simply because the male parents invariably destroy the offspring if an attempt be made to breed them in the permanent home or warren. I incline to believe we must look elsewhere for the explanation.

Firstly, then, a close atmosphere seems all-important to their development, as the old doe rabbit not alone denudes her breast of its natural fur covering wherein to ensconce them warmly all

around, she also closes up the usual entrance to the nursery firmly, even patting the soil down to exclude the colder outer air. In due time, as the young increase in size, &c., she makes "air-holes," commencing with very minute ones, which are gradually enlarged as the inmates gain strength and size.

These are known facts, to which I add one not heretofore noticed, which seems important; it has reference to the formation of the subterranean nursery, in regard to its shape and the evident "end in view." These minor tunnels, or nursery "stops," are invariably formed by starting a downward curve, at an angle of about 45°, which is continued beyond any line of sight the eye can be guided by on the outer side. They subsequently curve abruptly upward, with almost double this initial acuteness, ending in a shelved enlargement, with the roof boundary nearly uniformly three inches from the surface of the ground above and without.

What I feel constrained to uphold in regard to these first facts is, that herein exists a most subtle sanitary arrangement; that by these means a subdued genial air is admitted, the only fresh air the nursery receives, and whereon the nurselings thrive, strengthen, and grow. The facts would seem to support the theory that the mother-parent continues what must be its hard work—doubly hard and severe in these finishing overhead excavations—until the very keen power of scent they possess assures them that the outer air is slightly admitted through innumerable interstices in the soil above.

My second proposition, or indeed belief, based upon distinct observation, is, that the parent doe rabbit does not visit its young, even nocturnally, at certain times oftener than once in each 72 hours! Certainly sometimes not more frequently than once during the 48 hours comprising two days and two nights. The latter fact I have ascertained by carefully marking and observing the neatly closed entrance to the stops, and also by marks beneath an iron garden-gate, in freshly laid gravel, which the rabbits had to scratch aside before they could enter. Furthermore, I have every reason to believe that the parent rabbit ceases to transmit the customary natural scent at the time she approaches or acts about the "stop;" if, indeed, as is the case with some kinds of game birds, during the period of incubation, she does not lose it altogether. Certain is it no appreciable amount of scent remains about the stop in the early morning after the parent rabbit has visited its nursery during the past night.

[On the question whether animals have the power of ceasing to emit a scent at certain times, see the article on Pheasants in this week's number.—ED.]

Mr. J. D. Bell, of the *World* office, New York, writes as follows on the consciousness of time in horses:—

My own experience will not allow me to speak positively as to smell, but horses that I have met and carefully observed, were not peculiarly gifted in this respect. It was a common saying on "the plains" and in the mining regions of California, that mules, by the way very sagacious animals, which would well repay observation, "scent the redskin a mile away." I have made some inquiry on this point, but have been unable to find that the olfactories of the mule are really thus acute. I can bear testimony to the extraordinary powers of sight in horses. And I am inclined to think that they take more notes by the way through their eyes than through the nose. As none of your correspondents have called attention to it, I desire to recall the fact that horses have ears as well as eyes and noses. Their hearing is very acute, and I am inclined to think that the explanation of the detection of red-skins by mules, will be found in the educated ear rather than in the educated nose. It used to be said in the cavalry service of the United States during the war that "horses were the best pickets." I have seen them again and again in the dead of night prick up their ears when the men on their backs heard nothing. I have never seen them sniff or smell first. Listening was invariably the first movement. Then came sight. Horses have scanned the woods and chapparall with a care that no man could surpass. If the moving thing first heard and then seen was an unfamiliar object—more especially if it was moving along the ground—then I have seen horses sniff, smell, and snort. In horses the snort is expressive of aversion rather than fear, or perhaps of a sentiment compounded of both.

Horses learn the notes of the bugle, and I have often seen a trained horse turn in a direction opposed to that indicated by the pressure of his less experienced rider's leg. I have known horses which, after detecting the presence of moving objects by hearing and then by sight, during which time they remained perfectly quiet, change feet, and even paw the ground if the rider did not by his movement show recognition of the presence of what might be an enemy.

And what, it will be asked, has this to do with the question at issue? Simply this—horses think, horses reason, horses classify, horses remember. But I desire to offer a few remarks on Darwin's letter about the blind mare that stopped at every public-house on the road. My own explanation of the fact, and there must be hundreds of similar instances—is that the mare, by long-continued custom, became conscious of the time which should elapse between the respective stopping places. Horses have a great memory for time. What is the interpretation of the existence and improvements of our racing and trotting horses but that these animals have the power of remembering time, and the power of transmitting this improved registering and transmitting cerebral apparatus to their progeny. I will close this letter by relating a couple of incidents. I was speaking of my belief in this equine memory for time to an enthusiastic horseman of my acquaintance, the other day, and at the same time showed him Mr. Darwin's letter. He said that in his youth he had driven a horse, sound in every respect, on a "bread" route. He always served his customers in a certain order. After a while his animal knew all the places, and stopped in front of the store or residence where bread was to be delivered, without a signal from his master. If the master remained in any place longer than usual, his horse started off, but instead of going to the next customer, returned to the stable. This, said he, occurred again and again, not at one place, but at many places.

I served, during the recent war, in a cavalry regiment in the United States' service. The horses knew the time for "the relief," and if the relief did not come they became restive. On one occasion we changed the time of remaining on post from two to four hours. For the first two hours the horses behaved admirably; after that they were in constant motion, and had to be constantly restrained. Horses recognised the time for stable call—not merely "hunger"-call, but the proper time-call.

A gentleman in the north of Ireland, who gives us his name and address, sends us the following story of a dog:—

He was a terrier—a cross upon the skye—very intelligent, like all of his kind. He was given to me by Mr. C——, a gentleman residing upon Lough Foyle near Moville. He was brought from that to Derry in a steamer up the Lough, and from Derry to Buncrana down Lough Swilly by train. He therefore travelled two sides of an acute-angled triangle, about thirty miles in all by conveyance. The third side being about fifteen miles, but a mountainous and unfrequented route. He appeared at first very happy and reconciled, but one fine morning he was seen taking the road parallel to the railway back to Derry, and after my searching for him for some days and making every inquiry, we found he had returned, tired and worn out, to his old master, Mr. C., near Moville. It was evidently hard work, and he was two or three days on the road. This I consider an interesting case.—Here the dog did not go by the third side of the triangle—which if he knew how to do he would have done instead of exhausting himself by the long route he took—following the direction along which he came by steamer and train.

My theory is that the dog does preserve a very distinct, or at least tolerably distinct, notion of the route he was brought from home by, and that it is forcibly impressed upon him; but the great aid to his return is the *direction* of the sun or light. He knows that if he travels in a certain direction—say E.—he is going towards the morning sun, and W., towards the evening sun.

A correspondent, Mr. R. A. Pryor, Hatfield, sends us the following extract from the Rev. A. l'Estrange's edition of Miss Mitford's "Life and Letters":—

Miss Mitford (Letter of October 16, 1829, vol. ii. p. 277), had been dining in company with the late Dr. Routh, president of Magdalen College, Oxford, who "had a spaniel of king Charles's breed, who, losing his mamma by accident when a pup, was brought up by a cat: well, he and his brother, for there were two pups, orphans of three days old, were nursed by this

cat. But what I mention him to you for is to tell you the curious account which the doctor, a man of perfect veracity, gives of his habits—he is as afraid of rain as his foster mother, will never, if possible to avoid it, set his paw in a wet place; licks his feet two or three times a day, for the purpose of washing his face, which operation he performs in the true cattish position, sitting upon his tail; will watch a mouse-hole for hours together; and has in short all the ways, manners, habits, and dispositions of his wet nurse, the cat. Is not this very singular? But it's puzzling as well as amusing, and opens a new and strange view into that mysterious subject, the instincts of animals." Mrs. Routh, and Mrs. Blagrove (the mistress of the cat, who was present at dinner to-day), confirmed all the facts of the case. They say that one can hardly imagine how like a cat Romulus (the dog's name) is, unless one lived with him."

The following is from a letter of October 20, 1835 :—

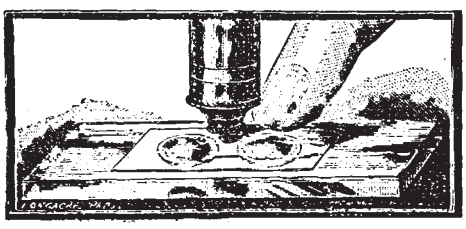
"Another characteristic of this hot dry summer (1835) has been the manner in which the large humble bees have forced open, torn apart the buds of my geraniums; an operation I never saw them perform before.

"Another novelty of this season has been that the splendid new annual, the *Salpiglossis picta*, has, after the first crop of blossoms, produced perfect seed without flower petals, a proof (if any were needed), that the petals which constitute the beauty of a flower, are not necessary to its propagation."

We may mention that Mr. C. H. Jeens has a cat and a dog, the latter now twenty months old, which, from the time the dog was a month old, have been in a relation similar to the cat and the pups in Miss Mitford's story, with a result somewhat similar. When the dog catches a mouse he treats it after the well-known manner of cats, pawing it, allowing it to run a distance, then pouncing upon it, and so on for many minutes.

SCIENTIFIC SERIALS

THE *Monthly Microscopical Journal* commences with the paper on "a new Callidina"; with the results of experiments on the Desiccation of Rotifera," by Mr. H. Davis, which was read before the Royal Microscopical Society in April, and in which the author, by means of several carefully performed experiments, proves that Rotifera, which survive after being exposed to a temperature of 200° F., or in a vacuum for some time, do not get desiccated, but only covered with an impervious gelatinous covering which retains a certain amount of moisture in them. This Mr. Slack shows to have been previously proved. Mr. Parfitt describes a new form apparently related to the Rotifera and the Annelida, named by him *Agchisteus plumosus*, with the oral aperture lateral and inferior. Dr. Braithwaite describes *Sphagnum papillosum* and *S. austini* in his paper on Bog Mosses; and Mr. F. Wenham has another valuable paper on "Binoculars for the highest powers." A new slide for the microscope, designed



by Mr. D. S. Holman, is described. It is a current cel or moist chamber for studying the blood and other organic fluids. The accompanying illustration will assist in explaining it. Two shallow circular cavities are excavated in a very flat thick glass slide, not far from one another. They are united by two or three grooves, which are cut as triangles in order that they may be of unequal depth in different parts. When the apparatus is to be used, each of the shallow cavities and the intermediate grooves are partly filled with the fluid to be examined, after the slide has been warmed by the hand, and a glass cover is laid over the whole, which soon becomes fixed from the cooling of the slide and the consequent rarification of the enclosed air. The grooves between the cavities form the field for inspection, and any degree of movement may be produced in the fluid which they contain by approaching the warm finger to the top of one of the cavities, as the air inside is thus made to expand and drive some of the fluid into the other which is not heated. There is scarcely any limit to the degree of delicacy of movement which may be attained with this instrument; the slightest movement, not sufficient to remove a body from the field of vision, being produced without difficulty after some practice.

SOCIETIES AND ACADEMIES

LONDON

Chemical Society, May 15.—Dr. Odling, F.R.S., president, in the chair.—Dr. H. S. Armstrong delivered a most able and comprehensive lecture on "Isomerism," pointing out that the generally received position theory was incompetent to explain many reactions which took place in the formation of metameric and isomeric substances. He suggested that the investigation of the thermal properties of compounds would establish facts which might ultimately enable us to obtain some insight into the matter.

Anthropological Institute, May 20.—Prof. Busk, F.R.S., in the chair.—A paper was read by Mr. Hyde Clarke on the Egyptian Colony and Language in the Caucasus. This was devoted to a part of a series of investigations to ascertain the comparative chronology of prehistoric races by the correlation of comparative philology with the study of physical features, monuments, weapons, &c. It identified the Ude language of the Caucasus, that of an expiring population, with the Coptic, and still more closely with the Hieroglyphic in minute and numerous details of roots, grammar, and structure. The resemblance of the Bzyb dialect of Ude with the Bashmurie Coptic illustrated the differences between Hieroglyphic and Coptic. The paper then proceeded to point out the conformity of strata in the linguistic topography of Caucasia and the Nile regions, particularly in the earlier epochs of Agaw and Abkhas, and of Furian and Akush. Hence the conclusion was drawn that the sources of Egyptian grammar were not in the late Semitic, but in the prior epochs, and that Egyptian grammar and civilisation belong to a remote period in the annals of civilisation, but still to a relatively modern period in the history of man. The author, accepting the history of Herodotus as to the conformity between the Colchians of Caucasia and the Egyptians, did not accept his theory that the Colchians were a colony of Lesodites. In the time of Herodotus and Pindar, the Colchians, now light, were as dark as the Egyptians.

GLASGOW

Geological Society, April 24.—Mr. John Young, vice-president, in the chair.—Mr. David Robertson, F.G.S., read a note on the "Precipitation of Clay in Fresh and Sea Water." He stated that in making some observations on the gradual deposition of particles of clay held in solution by water, he found that in fresh water these were held suspended for a long time before wholly subsiding, while salt water, or a mixture of salt and fresh, became comparatively clear in the course of a few hours. The results showed that water only slightly brackish had a great power in precipitating the clay, and from this he concluded that the great bulk of the clay carried down in solution by rivers must be deposited before it could reach any great distance from the sea shore. This might throw some light on the formation of deltas, and on the silting up of river courses within the influence of the tides. It might also assist in determining how far the glacial mud, for example, could be carried into the sea by tides and currents.—The chairman read a paper which he had prepared in conjunction with Mr. Robertson, "On the Composition of the Boulder and Laminated Brick Clays of the West of Scotland." The authors stated that their object was to ascertain, if possible, the conditions under which these clays had been deposited, and how far any of them were fossiliferous. For this purpose they had collected samples of clays from upwards of fifty localities. These, after being dried, were weighed, and then carefully washed. The results led them to regard as most probable the conclusion that the till or unstratified boulder clay was a deposit that had been laid down in water and formed from materials which land ice had carried seawards, the ice extending over the submerged tracts now covered by the boulder clay. This seemed to be borne out by the large percentage of fine glacier