that I advocate nothing of the sort. What I do advocate is to treat vectors as vectors, and versors as versors, and I show that the products of versors differ essentially from the products of vectors in that the associative rule applies to the former, but not to the latter. Prof. Knott justifies the treatment of quadrantal versors as vectors, because they are compounded according to the parallelogram law. It is true that the components of a quadrantal versor are so compounded, because every versor involves an axis; but the minus comes in, not on account of the axis, but on account of the angle of the versor, the very element which differentiates it from a vector.

I have said that $\nabla^2 = \frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2}$ is more consistent with analysis than $\nabla^2 = -\left(\frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2}\right)$, and I have remarked that in works on mathematical physics, even in Kelvin and Tait's "Natural Philosophy," the minus was dropped. A sign that can be so readily dropped has probably got no good reason for its appearance. In reply, Prof. Knott says that "when $\nabla^2 v$ occurs in ordinary non-quaternion analysis, it is used in the sense of the *tensor*, for only as such can it come in." This explanation does not explain; for "the name *tensor* is applied to the *positive* number which represents the length of a line" ("Hamilton's Elements," p. 164). Now the ordinary analysis is not limited to signless quantities, but embraces quantities which may be positive or negative. Why then is the minus dropped in an analysis where sign is essential? I asked for a proof of the principle that $\nabla(\nabla\omega) = \nabla^2\omega$; it is replied that "in quaternions there is no doubt whatever." Are we permitted, then, to doubt it as a truth in ordinary analysis, being true only in quaternions? If it is a matter of convention, no one desires two contradictory systems of analysis; if it is a matter of truth, it cannot be true "in quaternions" and not in ordinary analysis.

I have said that the rule $ij = k$ expresses what is true in space of three dimensions. Prof. Knott asks: "If a vector cannot be a versor in product combinations, what is the signification of the equation $ij = k$?" Let us first of all remove every ambiguity from the equation. We have then in all three cases: first, i and j both quadrantal versors; second, i a versor and j a vector; third, i and j both vectors. To distinguish between a quadrantal versor and a vector, let the former be denoted by $i^{\frac{\pi}{2}}$. Then $i^{\frac{\pi}{2}} j^{\frac{\pi}{2}} = -k^{\frac{\pi}{2}}$ means the forward order being taken, that a quadrant round i followed by a qudrant round j is equivalent to a quadrant round the opposite of k. Again, $i^{\frac{\pi}{2}} j = k$ means that the vector j, when turned through a quadrant round i coincides with k. Finally, ij means the unit of directed area which has i for base and j for altitude; for some purposes it may be represented by k on the principle that the axis of a plane may be specified by the axis which it wants; but at p. 92 of "The Principles of the Algebra of Physics," I have shown that the several types of products of vectors may be formed independently of that principle. Prof. Knott states that he fails to see what physical considerations have to do with mathematics of the fourth dimension. It is evident, however, that his perception cannot be taken as a criterion of truth, for every type of product of four vectors is geometrically real excepting the one which supposes them all independent of one another.

I have said that the rules for differentiation are much simplified when vectors and versors are not confounded. In proof of this I invite comparison.

I have said that the principles of quaternions can be greatly extended. In my papers will be found for the first time the extension of space analysis to logmarithmic spirals and to hyperbolic trigonometry. The connection of the latter with non-euclidean geometry is also pointed out. As further evidence of the fruitfulness of my notation and principles I may mention that I have just read before the Mathematical Congress assembled at Chicago two papers—one on "The Definitions of the Trigonometric Functions," the other on "The Principles of Elliptic and Hyperbolic Analysis." These papers give the trigonometry of the elliptic and hyperbolic surfaces.

As regards Prof. Knott's closing quotation from "Paradise Lost," I feel like the Senior Wrangler who, having read through the poem, remarked that it was all very pretty, but he didn't quite see what it proved. I close with a quotation which is from as good a book, and possesses more logical force: "Ye shall know them by their fruits. Do men gather grapes of thorns, or figs of thistles?" ALEXANDER MACFARLANE.

Chicago, Ill., August 26.

Astronomical Photography.

THE letter from Lord Rayleigh in your issue of August 24, on the subject of "Astronomical Photography," will, it is to be hoped, elicit some information from photographic experts.

Meanwhile, accepting what Lord Rayleigh says as to the present possibilities in the preparation of plates, I fail to see where any considerable saving is to be effected in the cost of the apparatus, as he appears to suggest.

For astronomical photography a pair of telescopes are required. The larger of these is employed to take the photographs, and the smaller acts as a guider. Supposing that plates could be obtained which were acted upon by visual rays, while comparatively insensible to the violet and ultra-violet light, this would simply mean that both the objectives would have to be made visually perfect, instead of having one of them as heretofore corrected for violet and ultra-violet light. A photographic objective is no more costly than a visual one of the same aperture; and as to mounting clockwork and dome, there could be no difference in expense.

Of course, if the necessity for a separate guiding telescope could be avoided by the adoption of Lord Rayleigh's suggestion, there would in general be some saving of expense; it should, however, be noted, that even when reflectors are employed for taking the photographs, it has not been always found desirable to dispense with the guiding telescope, though in this case, of course, the question as to the nature of the plates cannot arise at all.

In the particular instance of the instrument now proposed for Cambridge, the guiding telescope is already to hand in the shape of the present Northumberland instrument.

It is certainly easier to test the qualities of an objective corrected for visual rays than for photographic rays (if I may still use language which Lord Rayleigh has pointed out as incorrect). On this account it would, therefore, be desirable to have plates such as he refers to, rendered available for astronomers engaged in photographic work. ROBERT S. BALL.

Observatory, Cambridge, September 12.

P.S.—Sir Gabriel Stokes, after reading the above, writes: "I would ask whether in an orthochromatic plate the blue and violet are impressed more feebly than the rays which are visually the brightest. It may be so, but I do not happen to know whether it is."

The Constellations of the Far East.

WITH regard to the questions asked by "M. A. B." about the grouping of stars into constellations (NATURE, August 17), I venture to answer the last two, which the limited knowledge of an Oriental may partly meet, hoping thereby to interest some of your readers.

I do not consider that each race necessarily relies on its own plan in the fabrication of constellations. The Coreans and Anamese are said to be still adhering to the Chinese system, and till lately the Japanese were doing so. It is strange to find the latter, replete with so peculiar mythology, on which the national claim for high ancestry rests, possessing very few vernacular constellations.

Undoubtedly the Chinese system is of peculiar aspect. A name is given to a "Seat," which is sometimes a single star, but in general a group of stars, varying in number from two to twenty or thirty; and in one group, the Imperial Body-guards, they amount to forty-five. Occasionally the same stars are at once named collectively and individually; thus, the first seven stars of Ursa Major are grouped into Peh-tau or the North Ladle, of which the scoop consists of Shu α, Siuen β, Ki γ, and Kiuen δ, and the handle of Yuh-hang ϵ, Kai-yang ζ, and Yau-Kwang η. With Polaris as the centre, the heavens are radiantly divided into the twenty-eight "Inns" of unequal breadths, each division being denominated after its typical constellation, besides enclosing numerous Seats subordinate to the latter.

The fundamental idea of the plan is enigmatically expressed thus: "Sing (the star) is Tsing (the spirit)." Its solution con-

tinues: "Its body grows on the earth, and its spirit is perfected in the heavens." Consequently, various worldly facts and acts that have occupied the Chinese attention, not excepting some now quite forgotten, remind us of their past existence by means of the stellar and constellar names fashioned after them from fancied resemblances or analogies.

How closely this association of the heavenly and worldly phenomena was made, a few examples will suffice to show. The Bow-and-Arrow, though apparently separate, formed but one group, because an archer could perform well without an assistant; but, on account of the supposed impossibility of one's pounding, without an attendant to the mortar, the Mortar was distinct from the Pestle. Imitating the civil institutions of old times, Polaris, entitled the Emperor of Emperors, and his Empress, Imperial Heir, &c., constitute "Ché-wi Palace," with thirty-two subservient Seats, mostly named after officials. Besides, the four "Imperial Thrones" are established, one of which is surrounded with seventeen dependents, chiefly with the names of court-buildings in "Tai-wi Palace," while the other, amidst the "Celestial Emporium" has its seventeen subjects, named after provinces, market buildings, and measures.

For contriving the applications of the plan, the following methods seem to have been observed:

(1) Number, *e.g.* the Five Princes, Four Councillors.

(2) Magnitude, *e.g.* the Squire Captain, set apart from the Squires.

(3) Form, *e.g.* the Canopy, Celestial Coin, Ascending Serpent.

(4) Relation of positions, *e.g.* the Deep Water, Celestial Hook, and Celestial Pier, entirely and partly in, and along the Celestial River (the milky-way).

(5) Direction of the Compass, *e.g.* the South Gate, North Pole.

(6) Colour, *e.g.* Excrementum.

The objects and attributes resorted to for modelling the stars and constellations may be classified as follows:—

(1) Heavenly Bodies, *e.g.* the sun, moon, milky-way.

(2) Meteorological phenomena, *e.g.* thunder and lightning.

(3) Topographical Divisions, *e.g.* the field, tumuli, park, pond.

(4) Civil Divisions, *e.g.* Tsin (a province), Chang-sha (a shire).

(5) Animals, *e.g.* the dog, wolf, fowl, fish, snapping-turtle.

(6) Agricultural Products, *e.g.* bran, hay, gourd, cereals.

(7) Parts of Body, *e.g.* the tongue, penis.

(8) Human Actions, *e.g.* the cry, weep, slander, punishment.

(9) Family Relations, *e.g.* the son, grandson, adult, old man.

(10) Occupations, *e.g.* the farmer, weaving-woman.

(11) Buildings and Departments, *e.g.* the castle, granary, kitchen.

(12) Implements, Furniture, &c, *e.g.* the lock, drum, bell, bed, ship.

(13) Titles and Officials, *e.g.* the feudatory, ministers, generals.

(14) Heroes, *e.g.* Fu-yeh, Tsau-fu.

(15) Philosophical and Theological Notions, *e.g.* positiveness, virtue, prodigy, fates, fortune, wrong, &c.

As far as I could expound, the system implies certain peculiarities. First, it preserves some abstract notions, thus pointing the way towards investigations on the early Chinese speculations. Secondly, portions of the system severally harmonise with the conditions of the Chinese social system that existed for many centuries before the dawn of the Han dynasty (*circa* 200 B.C.), when it seems certain that the nomenclature was well-nigh finished. In the third place, I may mention that after careful revisions of the whole list containing more than three hundred names of the Seats, I have found but two that have had any reference to the sea, viz., "South Sea" and "East Sea," the rather vague notions of old usage indicating some uncivilised territories; and with this only exception there occur no names of marine beings such as Cetus, Delphinus, and Cancer. This fact probably justifies a historical theory that locates the cradle of Chinese civilisation on a land distant from the seas.

I do not know precisely what system is current among the Indians of the present day; but assuredly at least once they made use of their own plans, and mapped out the heavens into the twenty-eight divisions, each division with its typical constellations and their subordinates, as is often alluded to in the Buddhist writings of the North. The equality of number of the divisions in the Chinese and Indian systems is striking; but evidence favours the belief in their sporadic growths and analogous development. The Chinese records of the typical constellations date farther back than the epoch of their intercourse with the Indians; in fact, the Indian constellations, as is obvious from their mythic apotheoses and the articles of sacrifice, including such abomination to the Buddhist as blood and bird's-flesh, are essentially of Brahmanical type, and thus proclaim their priority in existence to the event of the Buddhist mission to China, which marks the era of the mutual acquaintance of the two nations.

When we see in the old Chinese works on Indian names, those of the Indian typical constellations, such as Rivata, Kamphilla, &c., not literally interpreted, but merely identified with those of the Chinese, such as Shi, Fang, &c., every two divisions of corresponding order seem to have had extents almost coinciding in the two systems.

Twan Chin-shi (*circa* 800 A.D.), a Chinese Pliny, in his "Miscellanies" has left us an extract from Indian records, registering the objects with which the Indians used to associate the forms of some typical constellations of their own. Of the Chinese typical constellations, the original resemblances or analogies can still be traced, through their names and characters, with the help of the descriptive remarks in cases of difficulty. Replying upon these authorities, I will now proceed to compare the cited objects of alleged resemblances or analogies, in order to see whether and how the fancies of the two nations converge into or diverge from one another, in the establishment of one most conspicuous, and thence typical constellation, out of the stars scattered over a division almost identical in the two systems.

Chinese names.	Remarks.	Objects of Indian fancy.
1. Niu (Taurus).	The bull with horns.	The head of a bull.
2. Wĭ (the Tail).		The tail of scorpion.
3. Liŭ (the Willow).	Curved, with a tip bent, like the willow (twig). In Chinese astrology, this is the patron of the snakes.	The serpent.
4. Wei (the Stomach).	The legs of a vessel for cooking.	Same.
5. Su (the Horn of Scops).		The head of deer (with antlers).
6. Ki (the Winnowing fan).		The horns of cattle.
7. Tsing (the Well).		A footprint.
8. Kwei (the unsettled).	Its character, combined with that for "foot," forms one for "kneeling," and its original hieroglyphic represents "one kneeling": hence it is probably of analogous plan with Hercules (kneeling).	The dimple of woman.
9. Kwèi (the Ghost).	The coffin (with corpse).	The Saint's Breast.
10. Pih (the Handle-net).		A hat.
11. Sing (the Star).	The hook.	The river-bank.
12. Fang (the Screen).		Beads of head-dress.

It appears from the above comparisons that sometimes quite analogous or even identical plans might sporadically grow among distinct nations, probably due to the pronounced readiness to be grouped afforded by the stars of not very different brightness and relatively situated in a manner which at once suggests a definite outline.

In conclusion, I should be inclined to state that the peculiarity, in cases where it exists, can no doubt be of great value to students of sociology, as it may help to some extent towards the attainment of various important discoveries. For instance, a Chinese constellation, Nü, or the Woman, is described as very much simulating Ki, or the Winnowing Fan; and this might be closely connected with the frequent occurrence in Chinese works of a figurative phrase, "to serve the fan and broom" in the sense of "getting married." On the other hand, as to the merit of its use for ascertaining the race-affinity, my opinion must be somewhat negative, for, while instances are not wanting of such remarkable analogies among such heterogeneous nations as the Chinese and Indians,

the subject is decidedly one of those social acquirements of highly transmissible nature, its present features being more the result of the national intercourse than that of the race-affinity.

KUMAGUSU MINAKATA.

15 Blithfield Street, Kensington, August 31.

Mr. Love's Treatise on Elasticity.

HAVING now returned to England, I have had an opportunity of examining my paper on wires (Proc. Lond. Math. Soc. vol. xxiii.), and I find that the discrepancy between my results and those given by Mr. Love, on p. 169 of his book, is due to a slip in my own work. On comparing my equations (11 and 15), it will be seen that in the latter equation the term $-\rho(\sigma\rho - \sigma r\cos\theta)^{-1}dw'/d\theta$ has been omitted. The value of w' is correctly given by equation 31, and when the omitted term is inserted in equation 32, the resulting value of g will be found to lead to values of the couples identical with those given by Mr. Love.

As I am strongly of opinion that the best way of constructing a satisfactory theory of shells and wires is to use the method of expansion, coupled with the hypothesis that all stresses which vanish at the surface may be treated (to a certain degree of approximation) as zero throughout the substance of the shell or wire, I am exceedingly glad to find that the apparent discrepancy is due to a small slip in my work, and not to any defect in the principles upon which the investigation is based. The question as to the values of the couples may now be considered to be completely settled.

A. B. BASSET.

September 28.

New Caledonian Pottery.

I AM extremely anxious to be informed on a little matter, and you are my only resource. In the *Journal of the Anthropological Institute*, August, 1893, vol. xxiii. page 90, Mr. J. J. Atkinson describes the making of New Caledonian pottery. The ingenious device of the pebble as a pivot is interesting. But Mr. Atkinson always says *he*. Do the men make pottery in New Caledonia, or is this a case of what the country school teacher termed the men embracing the women?

Washington, September 17. OTIS T. MASON.

SCIENCE IN THE MAGAZINES.

AMONG the articles of scientific interest in the magazines received by us, is one in the *Contemporary Review*, in which Prof. Weismann replies to Mr. Herbert Spencer's attack upon his views as to the distinction in the Metazoa between somatic and reproductive cells, and on the immortality of the latter, and of unicellular organisms. With regard to the experiments that have been made with a view to proving the occurrence of telegony, Prof. Weismann says:—

Herr Lang, of Stuttgart, has for twenty years experimented with dogs, without, however, ascertaining "a single fact that could be made use of for the advancement of the infection theory." Of course, in such a case negative results prove nothing; and the attempt must be made to determine the truth by new experiments. But as hitherto there have been no positive results from the observations that have been made; and as the most competent judges, namely, breeders who have a scientific knowledge, such as Settegast and Nathusius, and the late head of the Prussian Agricultural Station at Halle, Prof. Kühn, spite of their extensive experience in breeding and crossing, have never known a case of telegony, and therefore have great doubt as to its reality; it seems to me that *according to scientific principles, only the conformation of the tradition by methodical investigation, in this case by experiment, could raise telegony to the rank of a fact.*

In "A Note on Panmixia," Dr. Romanes attempts to remove any doubt that may exist in Mr. Spencer's mind as to whether Panmixia is a *vera causa* of degeneration, by showing that there are not excessive *plus* variations of an organ. Mr. Spencer had said, "If there are not excessive *plus* variations, the hypothesis of Panmixia is valid"—*ergo*, accepting Dr. Romanes' proofs, the doctrine is triumphant.

Mr. Robert H. Scott writes on "Weather Forecasts" in the *New Review*. He describes the difficulties that beset the weather prophet on all sides, and the various proposals that have been made for gathering in information which would increase their trustworthiness. Some of the proposals, *e.g.* the mooring of signal-ships in mid-Atlantic, are purely visionary, and intelligence directly received from stations in the United States or Canada is practically useless, for the condition of the atmosphere is constantly changing, and the rates at which storms cross the Atlantic vary considerably. The fact that the storms that visit us pass to the northward of the Azores would render those islands of little use to the Meteorological Office, even if a cable were laid to them; and all anticipations as to the advantages to be derived from mountain observatories remain unfulfilled, according to Mr. Scott. However, an examination of the results of forecasts prepared at 8 p.m. from 1879 to 1891 is fairly satisfactorily. Taking the eleven districts of Great Britain and Ireland, for which forecasts are made, it appears that, during the period mentioned, an average of 45·5 per cent. of the forecasts were entire successes, and 34·8 partial, thus giving a total of 80·3. Of the failures, an average of 6·6 per cent. were total and 13 per cent. partial. England (South) showed the highest rate of fulfilment, viz. 85 per cent., counting entire and partial successes together. "The least successful districts are, in order of their figures, the West of Scotland, the South of Ireland, and then the North of Ireland, and the North-west of England. The least successful forecasts are therefore our exposed west and north-west coasts."

Other articles of a scientific character in the *New Review* are: "Are we Prepared to Resist a Cholera Epidemic?" by Mr. Adolphe Smith, and "The Increase of Cancer," by Mr. H. P. Dunn.

Under the title "Atoms and Sunbeams" Sir Robert Ball gives, in the *Fortnightly Review*, a description of Helmholtz's shrinkage theory of the maintenance of the sun's heat, with particular reference to the "precise *modus operandi* by which, as the active potential energy vanishes, its equivalent in available heat appears." "Electric Fishes" is the subject of an article by Dr. McKendrick, and in it we find the investigations carried out by Fritsch, Bois-Reymond and Sachs, Burdon-Sanderson, and Gotch explained in an interesting manner. Before describing the minute structure of individual electrical organs the author makes the following remarks:—

About fifty species of fishes have been found to possess electrical organs, but their electrical properties have been studied in detail only in five or six. The best known are various species of *Torpedo* (belonging to the skate family), found in the Mediterranean and Adriatic Seas; the *Gymnotus*, an eel found in the lagoons in the region of the Orinocco, in South America; the *Malapterurus*, the rääsh, or thunderer-fish, of the Arabs, a native of the Nile, the Niger, the Senegal, and other African rivers; and various species of skates (*Raia*) found in our own seas. It is curious that the Nile is rich in electrical fishes, several species of pike like creatures (*Mormyrus* and *Hyperopisus*) possessing electrical organs the structure of which has been quite recently investigated by Fritsch. The electrical fishes do not belong to any one class or group, and some are found in fresh water, while others inhabit the ocean.

Two distinct types of electrical organs exist. One is closely related in structure to muscle, as found in the torpedo, gymnotus, and skate, while the other presents more of the characters of the structure of a secreting gland, as illustrated by the electric organ of the thunderer-fish. Both types are built up of a vast number of minute, indeed microscopical, elements, and each element is supplied with a nerve fibre. These nerve fibres come from large nerves that originate in the nerve centres—brain, or spinal cord—and in these centres we find special large nerve-cells with which the nerve fibres of the electric organ are connected, and from which they spring. We may, therefore, consider the whole electric apparatus as consisting of three parts: (1) electric centres in the brain or spinal cord; (2) electric nerves passing to the electric organ; and (3) the electric