brane. The effect of this when the sound-producing motion set in was to cause the membrane to wrinkle sharply towards the point of convergence; and, by experiment on the dead insect with the point of a pencil, it was easy to see that the sound was simply produced by this sharp wrinkling of the membrane. If a piece of stiff paper or parchment be held in the fingers, and the thumb be made to play sharply and rapidly upon it in succession, so as to produce a "kink" or wrinkle each time, a very fair representation of the sound of the insect will be produced. A captive insect, when the motion is slowing down, can be advantageously watched; it will then be seen that, as the sound divides up into separate clicks, the membrane becomes alternately wrinkled and flat. Beyond doubt the sound is no humming.

C. S. MIDDLEMISS

North-West Himalaya, March 14

Ferocity of Animals

I HAVE read with interest the article by Prof. Lloyd Morgan "On the Study of Animal Intelligence" in the present number of *Mind*, in which he touches upon the subject of entangling fact and inference which attracted my attention when reading "Mental Evolution in Animals" some time since.

I write to call Prof. Morgan's attention to the excellent example of "ejective inference" given by Dr. Romanes in his letter in NATURE for April 1 (p. 513), where he says of a rat that he "perfectly understood my object." Would it be troubling Dr. Romanes too much to ask him to explain the appearance a *wild* rat presents on "perfectly well understanding" the object of a human being's actions?

Churchfield, Edgbaston, April 5

F. H. COLLINS

Tropical Dew

HAVING had occasion to lay out a large quantity of iron hoes and picks, without handles, on the hard ground of an open inclosure in one of the driest districts in India (Bellary), where, in fact, these implements had been collected in the face of a scarcity, it was found, after they had lain a couple of months, that a thick, weedy, but luxuriant vegetation had sprung up, enough, though there had been no rain, to almost hide the tools.

The effect depositing tools on grass has had in stimulating its growing the writer has observed in the tropics before, but was at a loss to account for it, except upon some irresolvable theory of radiation or magnetism.

The whole phenomenon is cleared up by Mr. Aitken's paper on "Dew" in NATURE of January 14 (p. 256), dew being proved deposited, not, as generally thought, from the air above, but rising and condensing from the soil below; and the ground in India is always hygroscopic. The outer surfaces of the iron tools radiate of course quickly at night, and the stratum of air inclosed between the metal under surfaces and the earth is therefore saturated with condensing moisture.

That iron gratings laid on bare ground will raise a rank vegetation in places with only 10 or 15 inches of annual rainfall, and exposed to tropical heat, is a not unimportant fact, as being a readily available substitute for irrigation water, worth further investigation.

A. T. FRASER

India, March 26

The Climbing Powers of the Hedgehog

I AM advised by some of my friends to send you a notice of the mode in which hedgehogs may frequently escape from confinement, and of their habits.

I obtained a hedgehog last week, and put it in my kitchen. Every day it is placed in a small back area, about 12 feet square, during the day-time. The waste-pipes from the cisterns discharge into this area, and the animal frequently lies under these, and, as my servant says, "wallows in the trough like a pig." If he hears any noise he at once runs to a corner and rolls himself up.

On Wednesday the servant found him on the top of the partition wall between my area and the next. This wall is vertical, height 9 feet 6 inches. The top course but one projects 1 inch, so he must have climbed over this.

He has been watched in the operation. He climbs by the projecting mortar beds, which are rather rough, looking about him frequently to see if he is watched. He climbs up the house wall beside the pipe in the corner—an ordinary iron rain-pipe; but from the shoulder of the pipe, where it passes through the wall, to the top of the partition wall, there is a distance of 9 inches without any pipe, so up this portion and over the projecting brick course he must have climbed by clinging to the wall of the house or the partition wall.

Yesterday (Thursday) he repeated the ascent, and descended into the next area, where he was found this morning.

ROBERT H. SCOTT

6, Elm Park Gardens, April 16

STARS WITH BANDED SPECTRA[1]

THE spectroscopic survey of the northern heavens, undertaken conjointly by MM. Vogel and Dunér in 1879, has already progressed so far that its general results can be fairly anticipated—its immediate results, that is to say; for it is ultimately designed, not so much for a collection of statistics, however valuable and interesting, as for a criterion of change. This effect, however, must wait for the future—perhaps a remote future—to develop; we can in the meantime gather much present knowledge through labours inspired by still unfolded possibilities.

The first instalment of the first spectroscopic star-catalogue systematically executed, was published by Vogel in 1883 (*Publicationen* des astrophysikalischen Observatoriums zu Potsdam, No. 11). It covers a zone of the heavens extending from $-2°$ to $+20°$ of declination, and includes 4051 stars down to 7·5 magnitude. M. Dunér now sends us from Lund, in a catalogue of 352 stars fully ascertained to possess spectra of the fluted and zoned types, a work of special and extreme importance.

Stars with banded spectra fall into two perfectly distinct classes, of which the first is well exemplified in α Orionis (Betelgeux), the second in a 5·5 magnitude star close behind the Great Bear, numbered 152 in Schjellerup's Catalogue of Red Stars (*Astr. Nach.*, No. 1591), and called by Father Secchi "La Superba," from the extraordinary vivacity of its prismatic rays. The spectrum of Betelgeux (Fig. 1) shows a series of seven or eight well-marked dark bands (besides minor shadings) all abruptly terminated towards the violet, and dying out by insensible gradations towards the red. The impression upon the eye resembles that of a colonnade thrown into strong relief by a vivid side-illumination. Only three conspicuous dark spaces, on the other hand, interrupt the beams of 152 Schjellerup (Fig. 3); but their breadth is fully twice that of the flutings in the spectrum of α Orionis; and, still more remarkable, they *face in the opposite direction.* Their obscurity deepens slowly downwards towards their less refrangible sides, then suddenly, by a sharp transition, and with a singular and splendid effect of contrast, gives place to unclouded light.

The stars characterised by these two different qualities of absorption, respectively constituted Father Secchi's third and fourth spectral orders. M. Vogel, however, saw fit in 1874 (*Astr. Nach.*, No. 2000) to modify the arrangement by grouping the two varieties together as subdivisions of a single class. Nor was this a mere arbitrary change. It was the outcome of a far-reaching speculation regarding the course of development taken by the great army of suns marshalled in the profundities of space.

Secchi's classification involved no hypothesis of any kind; it was founded simply on appearances. But the idea that the colours, consequently the spectra of stars, may guide us to a knowledge of their comparative "ages," thrown out in a crude shape by Zöllner in 1865, had, meantime, made its way. Vogel's adoption of it as a means of rationalising observed particulars, gave it (perhaps prematurely) a recognised scientific status.

According to this view, the white stars forming Secchi's first order (of which Sirius and Vega may be taken as

[1] "Sur les Étoiles à Spectres de la Troisième Classe." Par N. C. Dunér. Mémoire présenté à l'Académie Royale des Sciences de Suède, le 11 Juin, 1884. (Stockholm, 1884.)

representative), are in the initial stage of their life as suns. Their energy is still unwasted; their temperature is enormously high; their light is not sensibly modified by absorption, hydrogen being the only constituent of their atmospheres capable of strongly intercepting their radiations. But with the lapse of ages, this early fervour cools down, and absorption gains strength. Hydrogen no longer stamps itself predominantly upon their spectra; metallic rays deepen and multiply; a dusky veil is drawn across each photosphere, stopping preferentially its more refrangible emissions, and thus imparting a yellowish tinge to the resulting light. The condition of our sun, as well as of Capella, Pollux, and Dubhe, is, in short, reached. Down to this point the history of all ordinary stars is the same. Here, however, a bifurcation in the path of development is reached. Two roads to extinction are now open to them. For, according to Vogel, the two varieties of banded spectra mark co-ordinate, not successive, stages in stellar existence. The choice, so to speak, once made, is definitive. Migration from one type to the other is impossible. Hence Vogel's abolition of Secchi's fourth type, and his distribution of such stars as Betelgeux and α Herculis on the one hand, and 152 Schjellerup and 19 Piscium on the other, into two alternative branches of his third. But let us look a little more closely at facts before admitting conjecture.

M. Dunér's Catalogue includes 297 entries under the heading Class III. *a* (type of α Orionis), to which in all 475 stars are so far known to belong. A particular description of each spectrum, from his own and others' observations, is appended; so that ample materials are provided for some few safe generalisations.

The first point to be noted is that the positions of the leading bands in *all* spectra of this kind are absolutely unchanging. The series is repeated with varying degrees of intensity from star to star, almost as if in stereotype. The shadings are, it would seem, in reality made up of fine lines very closely grouped. D'Arrest and Huggins, at least, repeatedly succeeded in thus resolving them, although to Vogel, even when employing most powerful optical means, they persistently maintained a nebulous appearance. Now a glance at the accompanying figures will show a symmetry in the arrangement of these bands suggesting that they result from the rhythmical vibrations of one highly complex molecular system. In other words, they betray the absorptive action of a single substance; particular identification is awaited; nor is it easily attainable. Great difficulty attends inquiries into the direct spectra of compound bodies, since the very means employed to render them luminous, also tend to destroy, by forcing them asunder into their constituent elements.

Besides this unknown substance, however, metallic vapours exist abundantly in the atmospheres of Betelgeux and its congeners. The grooved spectrum distinguishing them might in fact be regarded as superposed upon a modified Fraunhofer spectrum. Not only in its bright spaces, but even across its dusky flutings, a crowd of significant dark rays can be perceived. Their number, as disclosed by the 27-inch Vienna refractor in September, 1884, in the spectra of β Pegasi and α Herculis, took Vogel altogether by surprise (*Publicationen*, Potsdam, No. 14, p. 22). Yet he and Dr. Huggins had already measured no less than 95 such in the analysed light of Betelgeux. Some of these can be identified with terrestrial substances. Sodium, iron, magnesium, calcium, and bismuth, are without doubt incandescent above the photosphere of that star. Lines of hydrogen have also been made out, and its presence is certified by Dr. Huggins's photographs. Its absorption is, however, inconspicuous in all, and imperceptible in most spectra of this description.

One of their most singular features, as yet unexplained, is that dark metallic rays form the sharp boundary of many of the flutings. Thus calcium-lines (wave-lengths 616·4 and 585·6) respectively terminate, on their more refrangible sides, the bands numbered 2 and 3 in the figure; strong contiguous lines of calcium and iron limit band 4; band 5 ends with the well-marked iron lines of wave-lengths 545·0 and 544·4, and band 8 with that of 495·8; band 7 with the solar group *b*; band 9 with a deep furrow of unknown origin. These coincidences are extremely puzzling; for, as M. Dunér remarks, they can scarcely be accidental.

Stars with fluted spectra are all more or less deeply tinted with orange, owing to the stoppage, by a general absorption, of by far the greater part of their blue rays. Their actual emissions must then be very greatly in excess of those reaching outer space. Stripped of its surrounding atmosphere, our sun, it is computed, would leap up to some three or four times its present lustre; but in stars like Betelgeux, absorption must at least quadruple its solar effects. This consideration is of fundamental importance in any estimate of the relative luminous power of the stars.

Fifty-five members of Class III. *b* find a place in the Lund Catalogue. These are all that have hitherto been discovered. Yet exploration, in their case, is more complete than with the previous type, the broad, deep zones of their spectra being distinguishable in objects much too faint to show the narrower groovings of Class III. *a*. No star of this kind is as bright as the fifth magnitude, while eight between ninth and tenth are included in M. Dunér's list. Thus, although the fluted spectra already examined outnumber those in zones (as we may call them for the sake of distinction) scarcely nine times, M. Dunér considers that the real proportion of their excess is at least fifty to one.

The rare objects constituting Class III. *b* are amongst the most interesting in the heavens. For they exhibit in their spectra the unmistakable signature of that substance which, more than any other, deserves to be called the material basis of life. Father Secchi (their original discoverer) regarded them from the first as "carbon-stars;" but Dr. Huggins in 1872 tested the supposition (for it was then little more), and rejected it as disproved. There is now no doubt that the Roman observer was in the right. The three conspicuous bands of dense absorption visible in such spectra agree in position quite closely with the emissions of carbon-vapour glowing in the electric arc. Dr. Huggins gives scanty details of his observation (see Schellen's "Spectrum Analysis," ed. 1872, p. 504); he is rarely in error; but on this occasion was perhaps misled by the facile emergence of acetylene-bands, of which the blue one falls just in the intermediate position indicated by him as fatal to the suggested identity.

Besides carbon, sodium is without doubt present in the atmospheres of these remarkable bodies; and there are signs of further metallic absorption, notably by iron. Their rays being, however, too faint to bear scrutiny with a narrow slit, the finer features of their spectra remain, for the present, unrecognisable. Yet we cannot avoid being struck with the circumstance that their most prominent constituent elements are precisely those which kindled in the great comet of 1882 as it approached the sun.

The "zoned," like the "fluted" stellar spectrum, is, in general outline, invariable, though capable of endless individual modifications of tone and detail. It is as if one fundamental sketch-plan were filled in with the most diverse depths of shading.[1] Another point on which all such stars agree, is the redness of their light. The violet end of their spectra is, uniformly, all but obliterated; not necessarily through original deficiency. The more refrangible emissions of 152 Schjellerup may, for aught we

[1] See Figs. 4, 5, and 6; the last a supposed example of a "transition" spectrum given by a star in course of passing from Class II. *a* (solar type) to Class III. *b*.

can tell, be as copious as those of Sirius or Vega. But they are intercepted in a deeply-laden atmosphere, which can indeed be escaped by only a small per-centage of their entire radiations. This explains at once the uniform inconspicuousness of such objects. A star of this class should possess, say, a hundred times the radiating surface of Vega, to send us, from an equal distance, the same quantity of light.

No star of those yet known to show banded spectra of either kind has an ascertained parallax. This is not wonderful, since the stars at measured, or perhaps measurable, distances from the earth, constitute a scarcely perceptible fraction of the whole. Still, the fact remains that all members of the two classes under consideration are indefinitely remote. We are accordingly without the means of estimating, even in the most general way, the real quantities of matter contained in, or of light emitted by, them. We can only say that their dimensions must be very great in proportion to their apparent magnitudes.

The question of their distribution is of much interest, as involving their relations to the vast ground-plan of the sidereal system. And one circumstance connected with it becomes immediately evident. This is, their largely predominant occurrence in and near the plane of the Milky Way. M. Dunér, it is true, considers that they merely obey the general law of stellar condensation. But this law applies more and more closely to the lessening orders of stars; and we have just seen that, physically, stars characterised by strong absorption should rank with stars optically by many degrees their superiors. The hypothesis, then, of some special connexion with the galactic streams and rugosities is by no means excluded; and it is countenanced by statistics as to the distribution of red stars in the southern hemisphere, recently afforded by M. Pechüle ("Expédition danoise pour l'Observation du Passage de Vénus," 1882, p. 38).

One of the most assured peculiarities of stars with banded spectra is their marked tendency to fluctuations of light. Amongst innumerable examples of this connexion may be cited "Mira" Ceti, and Gore's "new star" in Orion, both of which display brilliant prismatic flutings. Nearly all variables, in fact, save the few which complete their cycle of change in a few days, belong to one or other of the subdivisions of Class III. Whatever may be the secret of their constitution, it is indissolubly bound up with the still mysterious cause of stellar variability. We can scarcely penetrate the one without divining the other. Already something is gained by the mere fact of the connexion being established. We learn from it that the steadfast shining of a sun or star is conditioned by the quality of its surrounding gaseous envelope. Continuous study, then, of the spectra of variables affords probably the best chance of progress in knowledge of their nature. M. Dunér's incidental observations show that the reinforcement and extension of banded absorption apparent at minima, do not sufficiently explain the diminution of light, which must accordingly be in part due, either to a real failure of emissive power, or to an increase of general absorption. The analogy of sun-spots favours the latter alternative.

M. Dunér concludes his valuable memoir with the admission that the order of stellar development postulated by Vogel, and advocated by himself, may, after all, be the inverse of that pursued in nature,—a possibility surely worth thinking about.

The heavens are no longer in our eyes "incorruptible." Reason and revelation alike lead us to seek for symptoms of growth and decrepitude in their bright inmates. Not in human affairs alone "the old order changeth, yielding place to new." But the subject is one on which we are without the guidance of experience, and can scarcely hope to acquire any, regard being had to the almost infinite disproportion between our hurried notions of time, and the unimaginable leisureliness of cosmical progression. Caution is then all the more needful, if we would avoid wide wandering from the truth.

Now it has to be objected to Vogel's scheme, that it gives no account whatever of suns in process of becoming. Yet they must be as numerous, one would think, as suns in process of decay. From the summit of brilliancy and vigour, the course of decline is traced downward towards the final quenching. But what of the other branch of the curve? Stars now at their acme of splendour must have passed through long periods of preparation. Sirius and Canopus, we are fully assured, did not all at once blaze out in their present radiance. What, then, we cannot abstain from asking, was their anterior condition? What quality of light did they emit? How were their atmospheres constituted? What kind of spectra, in short, would they then have afforded? A system of classification, based on the supposed order of stellar development, in which no account is taken of this wide branch of the inquiry, must be regarded as essentially incomplete.

A. M. CLERKE

THE INSTITUTION OF NAVAL ARCHITECTS

THE twenty-seventh annual session of the Institution of Naval Architects, held at the rooms of the Society of Arts, was one of the most successful of the series. The meetings began on the 14th inst. and concluded on the 17th. There were seven sittings, averaging from three to four hours each, and no less than eighteen papers were read and discussed. As on previous occasions, too much was attempted to be done in the time available, with the result that some important matters received scant notice. This may be to some extent inevitable in a Society embracing such wide and varied interests, yet meeting but once a year. But it may be anticipated that the autumn meetings in the outports which are now contemplated may somewhat relieve the congestion in future.

Lord Ravensworth presided as usual, and delivered a Presidential Address, in which various matters of interest were touched upon, *inter alia* the use of liquid fuel instead of coal in steamships, the development of triple-expansion engines, the prospects of shipping and the statistics of shipbuilding, including the extended use of steel. It may be hoped, although the immediate future scarcely justifies the expectation, that before the next meetings a change in circumstances may enable the President to speak more cheeringly. On the other hand, it is an undoubted fact that the period of depression through which the country is now passing is forcing into prominence inquiries into possible economies in the construction and propulsion of ships which might otherwise have been neglected.

No less than seven of the papers read had relation to the propulsion of steamships. The first on the list—"On the Speed Trials of Recent War-Ships"—was read by Mr. W. H. White, Director of Naval Construction. It contained a succinct account of the remarkable advances made during the last quarter of a century in the speeds and propelling machinery of war-ships. The fact that huge battle-ships carrying enormous weights of armour and guns are now driven at speeds of 17 to 18 knots—20 to 21 miles per hour—is sufficiently remarkable. Yet the fact that such a ship, weighing 10,000 tons, can be driven 9 knots in an hour with an expenditure of only 1 ton of coal is no less striking. Much has been learnt, too, of late years as regards the influence of *form* upon the resistances of ships; thanks, in great measure, to the researches of the late Mr. Froude, whose work received the substantial support of the Admiralty. In the paper above mentioned it was shown that by suitable selection of form, the *Howe*, a vessel of 9600 tons, 325 feet long and 68 feet broad, was driven as easily as the *Warrior*