CONCAVE GRATINGS FOR STELLAR PHOTOGRAPHY.—Some experiments have been carried on quite recently at the Johns Hopkins University to investigate the value of the use of concave gratings for stellar spectroscopy, and the results obtained bid fair for further trials (*Astrophysical Journal*, vol. vii. No. 3, March). The methods originally suggested by Prof. Rowland have been developed; Dr. Poor has derived the formulæ, and directed the construction of the apparatus, while Mr. Alfred Mitchell has made the experiments and photographs. The method finally adopted was the direct one, the grating being the objective and spectroscope combined; the light from the star was thus reflected directly from the grating to the photographic plate. The best position for general work was found to be that in which the centre of the photographic plate falls on the axis of the grating. From the simplified general equation

$$r = \frac{\rho}{1 + \cos v}$$

in which ρ is the radius of curvature of the grating, R and v the spherical coordinates of the light source, and r and μ those of the curve on which the spectra are brought to a focus (R being ∞ and $\mu = 0$), it was found that those parts of the spectra where cos μ could be assumed equal to unity, were brought to a focus on a circle whose radius is given by the above equation. The equation really represents a parabola, but within certain limits the spectrum may be considered normal. For a grating of medium dispersion, the entire spectrum will be practically normal; but with one giving larger dispersion, as a Rowland 21-foot, the scales of the middle and end differ by one and one-half parts in a thousand at a distance of 3° from the axis. It is necessary, therefore, that parabolic curved photographic plates must be used, but within certain limits they may be circular. In the experiments a small Rowland concave grating, of 15,000 lines to the inch, radius of curvature one metre, and ruled surface 1 × 2 inches, was employed, the photographic plates being bent to the proper radius. The spectra of Sirius, Capella, and Rigel obtained were 5 cm. long, and from 0·1 mm. to 1·5 mm. broad, and showed many lines.

Thus with an exposure of forty minutes, the spectrum of Sirius showed "16 hydrogen, H and K lines, and 15 other distinct fine lines." Capella, with forty minutes' exposure, gave F.G.h.H.K., and about fifty fine lines. It may be mentioned that these experiments were made on the fifth floor of the Physical Laboratory, "subject to the jar of street-cars and city traffic, as well as to dust and to the glare of electric lights," so that the results were not obtained under the *best* conditions.

A CATALOGUE OF 636 STARS.—No. 4 of the *Mittheilungen der Hamburger Sternwarte* contains a catalogue of stars observed by Herr W. Luther in the years 1885–92 with the meridian circle of the Hamburg Observatory. The observations in R.A. were made after the eye and ear method: those for declination by bringing the stars between two horizontal wires. The positions have all been reduced to the year 1885, and a comparison is made with the catalogue of the Astronomische Gesellschaft Zonen.

THE PREPARATION OF MARINE ANIMALS AND PLANTS AS TRANSPARENT LANTERN-SLIDES.

AT the request of the editor of NATURE, I give an abridged account of my essay in the volume of original researches published to commemorate the establishment of the Sheffield University College by Royal Charter in 1897. I shall confine myself mainly to the animals shown in the reproductions from four of the series of photographs taken by Mr. J. E. Atkinson, of our College, from some of my slides. Though on the whole these reproductions show the general facts fairly well, much of the minute detail is unavoidably lost, which is quite distinct when the mounted animals or photographs are somewhat magnified.

It is about eleven years ago that I first attempted to prepare lantern-slides with marine animals. At first I did not mount them in balsam, but very soon found that this is in almost every case not only desirable but even essential, since they so readily become mouldy, sometimes are attacked by mites, and are often far too opaque. Some also scale off from the glass and break to pieces, unless mounted. The success of the preparations depends almost as much on the proper mounting with balsam as on anything else, and sometimes the only way to get excellent results is to mount several, and pick out the best, which perhaps cannot be known until the specimens are finally mounted in balsam.

The methods necessary in mounting vary greatly in the case of different animals. Often little else is wanted than to arrange them properly on a lantern-glass, so that they touch it more or less completely all over their under surface, and then to drain and dry them. Many readily adhere round the drying edges, before the central parts are dry; and being thus fixed, they do not shrink laterally on further drying, but merely become thinner. On finally drying completely they may partially scale off, and it may be desirable to gum them down in one or more places, lest they should become loose when mounted in the balsam. There are a few animals that will not adhere at all to the glass, and yet shrink greatly. This circumstance has so far prevented me from making satisfactory slides of *Actiniæ*. I have succeeded with every other group.

Few animals are more easy to prepare than small flat fish like soles and dabs, 2 or 2½ inches long. These are killed by putting them into dilute alcohol, and arranged on the glass as soon as dead, whilst still limp. The chief matter is to arrange out the fins neatly. These soon dry, and adhere well; but in order that the side near the glass may keep flat, it is desirable on further drying to adopt a plan which I find most useful in many other cases. Very few, if any, animals will adhere in an objectionable manner to thin paper soaked with bees-wax, and, having laid such over the animal, pressure can be applied. What is wanted is that this pressure should be fairly uniform, and not merely on the thick parts. This is easily done by having a stout lantern-glass covered by two or three thicknesses

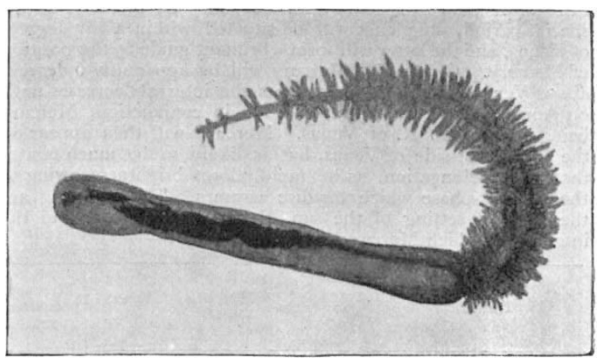

FIG. 1.—*Priapulus* in natural state.

of fine thin flannel, which is pressed down by a smaller or larger weight, so regulated as not to crush or distort the animal, but rather to retain as much as possible the natural shape and show the internal structure. The animal then dries through this flannel, and at the same time keeps sufficiently flat on the glass. Finally, any specially high parts can be pressed down by using a flat glass without flannel and a heavier weight.

A considerable variety of marine worms can be made into most excellent transparent slides, showing not only their general shape and colour, but also much of their internal structure. *Sabella* may be named as a specially good example. Such animals should be killed by keeping them for a short time in dilute alcohol. The aim should be to dry them before partial decomposition sets in and destroys the small blood-vessels. If all goes on well it is possible to dry and permanently preserve such worms as *Nereis*, so as to show not only the chief blood-vessels but even the smallest branches, and the blood may retain its red colour for years without any apparent change.

As an example of an animal mounted without staining, I give in Fig. 1 a reproduction from *Priapulus*. It should be killed by putting it into fresh water, and left in it so long that the body just begins to get limp. It can then be easily arranged on the glass, and adheres fairly well without lateral contraction. If mounted at once or previously kept in alcohol the body is too hard and will not adhere to the glass, and on drying contracts so much laterally as to become very unlike the living animal. The internal anatomy and general structure are best seen by cutting the animal open from end to end, and staining the whole with Beale's carmine or Kleinberg's hæmatoxylin. When thus

prepared, the muscular structure of the body-wall and the general internal anatomy are seen to great perfection.

I have not yet succeeded in preparing specimens of *Arenicola* when in their natural condition, so as to show their internal structure well, but have made some most excellent preparations by carefully cutting the animal open from end to end, spreading it out on the glass, and displacing the intestine and its appendages so as to be quite clear of the body, but yet to show the numerous blood-vessels passing to the lateral branchiæ from the main trunks along the intestine, which, however, are imperfectly seen in Fig. 2, which I give as an illustration of what may be done by partial dissection. Of their kind no preparations could be more satisfactory than some thus made, since the general anatomy is seen to great perfection, and the colour of the blood has remained unchanged for years, though in other cases, from some unexplained cause, it quickly turned brown.

It was the desire to preserve some of the beautiful Nudibranchs that led me to mount animals on slides. The lovely purple *Eolis* quickly loses its colour in alcohol. It should be killed in dilute alcohol, but kept in it a very short time, and then arranged on the glass and nearly dried. A strong solution of gum should then be placed over it, and the whole kept damp over diluted alcohol, to enable the gum to soak well into the animal, so as to protect the pigment from the balsam, in which it is soluble. I have specimens which have been mounted for more than seven years without showing any further change than the loss of a bluish tint, which occurs almost at once.

Most excellent transparent slides may be made with the so-called spider crabs, and these sometimes show well the

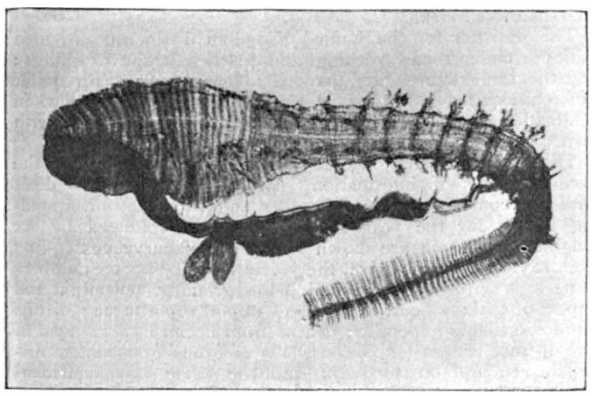

FIG. 2.—*Arenicola* partly dissected.

manner in which they are covered with a growth of sertularians, sponges, ascidians, &c. The animal is properly arranged on the glass, and at first gentle, and afterwards stronger, pressure applied, using waxed paper and glass covered with flannel; by which means the whole may be pressed flat without material distortion. The body and legs may indeed be made a little wider than natural, but this is to a great extent counteracted by lateral shrinking. At all events the general results are extremely good, and the muscles in the legs well seen.

Various species of Mollusca can be prepared so as to show their general anatomy by dissolving away the shell with hydrochloric acid in diluted alcohol. The organic matter of the shell retains the natural form, and shows the attachment of the various parts of the animal, which may be stained or not according to circumstances. Judging from what I have done, it will be possible to prepare instructive slides from the shells alone of some species, by dissolving away the carbonate of lime and mounting the membranous residue, which retains the natural form and much of the colour.

When first I attempted to mount Medusæ as lantern-slides, I looked upon them as most unpromising, and never imagined that it would be possible to prepare such specimens as I now possess. The first step must be to dissolve out all the included salt. For some years I used to put the newly caught specimens of *Aurelia* into methylic alcohol, diluted with half its bulk of fresh water, and after leaving them in for some hours, with occasional movement so as to prevent adhesion to the glass, they were digested over and over again with fresh diluted alcohol. Specimens so prepared are so colourless and transparent that little of the general structure can be seen, but if kept many months in alcohol they turn somewhat brown-yellow and show their structure moderately well. On the whole it is, however, better to stain them. I have experimented with a great variety of colouring-matters, but find that the best are tincture of madder, Beale's carmine, methylene-blue, port wine, and tincture of galls. The canal-system and the general structure are well seen when Beale's carmine is used, but the colour is unnaturally bright, whereas the colour of madder is more in harmony with nature. Methylene-blue gives good results with fresh specimens, but does not stain those which have been kept long in alcohol.

Though I have many splendid specimens prepared as described, my last year's experience shows that, at all events for some Medusæ, a 4 per cent. solution of formic aldehyde is far better than alcohol. Into this the newly-caught animals were at once put, and it was subsequently used to dissolve out the salt. The superiority of this over alcohol is that Medusæ retain their form almost unaltered, and the most delicate parts can be moved about and arranged without fear of tearing. The only serious objection is that the very delicate fringe of *Aurelia* may be too rigid to be properly extended. No such objection exists in the case of *Cyanæa* or *Chrysaora*; and *Cyanæa* may be stained so as to be of nearly the natural colour, which is other-

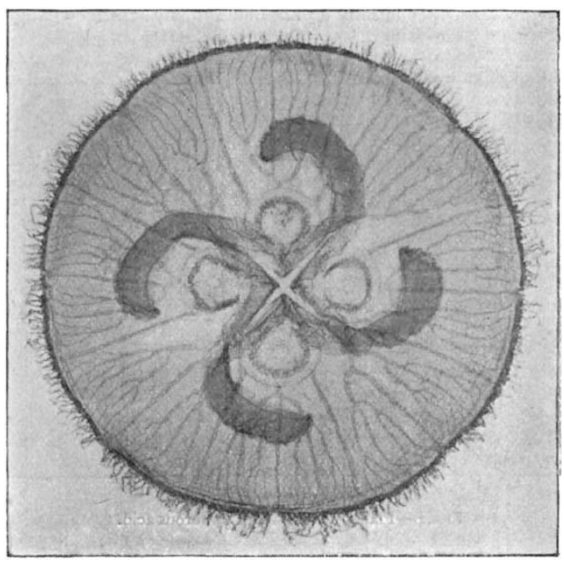

FIG. 3.—*Aurelia* stained with carmine.

wise lost. In Fig. 3, I give an illustration of an *Aurelia* stained with carmine when in a 4 per cent. solution of formalin to which a little sulphurous acid was added.

In mounting Medusæ some special methods are necessary. Having removed the salt and stained the specimen as thought desirable, the lantern-slide glass is put into one of the usual developing dishes, and the animal floated out, and to some extent properly arranged, when under the liquid. The specimen may then be half an inch thick in the centre. No attempt should be made to dry it at once, since the greater part of the included liquid usually diffuses out, and nearly the whole can be drained off by keeping the slide inclined and covered up so as not to dry. In some cases the liquid passes off badly, but comes off rapidly, if a solution of gum is spread over the animal. As the edge dries, it should be covered with a strong clear solution of gum to which a little glycerine has been added to make it less brittle when dry, and this process continued until the whole specimen has been covered with gum. It should then be kept for some days in a wet state, so that the gum may soak well in, and any small bubbles not easily removed mechanically may disappear by absorption. At first I used to keep the specimens in a developing dish over a little water, covered up with a closely-fitting plate of glass, but sometimes in the course of a single day they became coated with a long growth of mould.

If, however, instead of water they are kept over alcohol diluted with an equal volume of water, they may remain wet for weeks, without any such growth of mould or such alteration in the gum as is produced by the action of stronger alcohol. It is very desirable not to finally dry too quickly, but, as it were, to anneal the specimens; since contraction may give rise to sufficient tension to cause them to crack and scale off from the glass.

I must now consider cases in which it is desirable to get rid of part of the colouring-matter, either natural or developed on keeping. Diluted sulphurous acid is very useful for this purpose, and remarkable results can be obtained with small fishes. If plaice about 2¼ inches long are kept in alcohol and then for a few weeks in diluted sulphurous acid, the earthy matter of the bones is dissolved out and only cartilage left; the general colour is reduced, and the thickness diminished; but strange to say, the arteries and enclosed blood are so little altered that when the specimens are mounted the aorta and branching arteries are well seen over the whole animal, as shown in Fig. 4, which, however, fails to show the more minute arteries, quite visible in the original.

Having duly prepared the dried animals, it may not be convenient to mount them at once in Canada balsam, especially when living on a yacht. They may then be kept in tin boxes with flannel which has been well dried at a fire, so as to absorb any moisture that may be in the air. When thus kept, even for many months, they usually do not undergo any sensible changes and do not go mouldy.

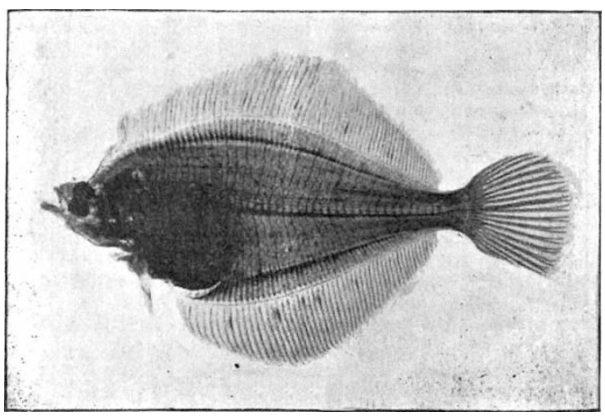

FIG. 4.—Plaice treated with sulphurous acid.

I must now conclude by describing the methods employed when finally mounting the specimens in Canada balsam. At the four corners of the glass should be gummed small pieces of blackened cardboard, of such a thickness that the cover-glass will just clear the object and not rock. The glass with the animal should be kept for a short or longer time in benzole; and, in the meanwhile, the cover-glass should be warmed on a suitable stand over a small burner, and a fair quantity of liquid balsam placed in the centre. The glass with the animal is then taken out of the benzole, and carefully placed over the balsam, so as to catch up as few bubbles as possible, the benzole causing the greater part to burst and disappear. If too little balsam has been used, more is easily run in between the glasses; and if only a few bubbles have been caught up, they soon disappear. If there are more than desirable, they can be got rid of by keeping the slide slightly inclined until they rise to one edge and can be removed. After keeping cold for a few days, for the balsam to harden the edges, it should be bound round with thin paper of the best quality, made thoroughly wet with gum. When this dries, contraction may squeeze out some superfluous balsam. This paper should then be varnished, and finally strips of good black paper should be *glued* well round the whole. All possible care should be used to enclose the balsam thoroughly, so as to avoid its turning yellow, and to prevent leakage, when the slide becomes warm in the lantern.

I have, however, had scarcely any trouble from this cause, since I have so completely fastened it in that the glasses or binding yield sufficiently. I may also say that though many of my slides have now been made for more than seven years, I have not observed any deterioration, but, on the contrary, many have greatly improved owing to the balsam having more completely penetrated into the tissues, and the included air disappeared. When this has taken place, the specimens are far more transparent and show their structure far better than the living or dead animals. Nearly all my slides have been kept in the dark, but some have been kept about the same time in a strong light at the Sheffield Public Museum, Weston Park, and, as far as can be judged, have not faded, even when imperfectly mounted.

H. C. SORBY.

OUR MINERAL WEALTH.

IT would be difficult to conceive of a more concise and clearly expounded compilation of statistics and general information regarding mines and mining than that presented in the Third Annual Report upon the Mineral Industry of the United Kingdom of Great Britain and Ireland, which has been issued by the Home Office in the form of a Blue Book for the year 1896. The volume before us is a synoptical review of the condition of our own mineral industry, as well as that of other countries, which reflects unbounded credit upon its author, Dr. Le Neve Foster, and those who have assisted him in the work. It is divided into six parts, under the respective titles of persons employed, output, accidents, prosecutions, general remarks, and mineral statistics of the Colonies and foreign countries. It contains, in addition, nineteen appendices, and concludes with an exhaustive index.

The statistics for the United Kingdom distinguish between mines or underground workings and quarries or open workings; and the same figures are marshalled again and again under different aspects, so as to show their varying significance when coalfield is compared with coalfield, inspection district with inspection district, and county with county.

The first four parts include sixty-nine tables, in which the various classes of information susceptible of being so dealt with are compared with each other and with the corresponding figures for the year 1895. These are followed by six diagrams, on which are shown by means of curves, extending from 1851 to 1896 inclusive, the yearly variations in the numbers of persons employed above and below ground; the output and export of coal; output, export, and import of iron ore; deaths due to accidents generally; deaths from accidents, arranged in five distinct classes (explosions, falls of ground, in shafts, miscellaneous, and on surface); and the average quinquennial death-rate per 1000 persons employed, classified in the same way as in the last case. In Part iii. short descriptions are given of the circumstances under which the most important accidents of the year occurred; and throughout the volume many pertinent remarks are made, which serve to throw light upon the construction and meaning of the tables, point to the conclusions which they justify, and infer the lessons that are to be learnt from their perusal.

Turning now to a consideration of the subject-matter, we find that, taken altogether, there were 725,803 persons employed in or about mines during the year under review—576,325 working in the mines, and 194,478, including 5114 females, working on the surface. Of these numbers 678,690 were employed at 3260 coal mines, 16,819 at 136 iron mines, and 30,294 at 720 other mines. In addition to this there were 112,829 persons employed at 7758 quarries.

The quantity and value of the principal classes of minerals mined and quarried were as follows:—

Name of mineral.	Quantity.	Value at the mines or quarries.
	Tons.	£
Clays	11,341,782	1,442,069
Coal	195,361,260	57,190,147
Iron ore	13,700,764	3,150,424
Limestone ...	11,011,350	1,215,604
Sandstone ...	4,507,745	1,417,985
Slates and slabs ...	586,933	1,338,256