KEATS'S GREEK URN.

WHEN the young poet wrought so unaware
From purest Parian, washed by Grecian seas,
And stained to amber softness by the breeze
Of Attic shores, his Urn, antiquely fair,—
And brimmed it at the sacred fountain, where
The draught he drew were sweet as Castaly's,—
Had he foreseen what souls would there appease
Their purer thirsts, he had not known despair!
About it long processions move and wind,
Held by its grace,— a chalice choicely fit
For Truth's and Beauty's perfect interfuse,
Whose effluence the exhaling years shall find
Unwasted: for the poet's name is writ
(Firmer than marble) in Olympian dews!

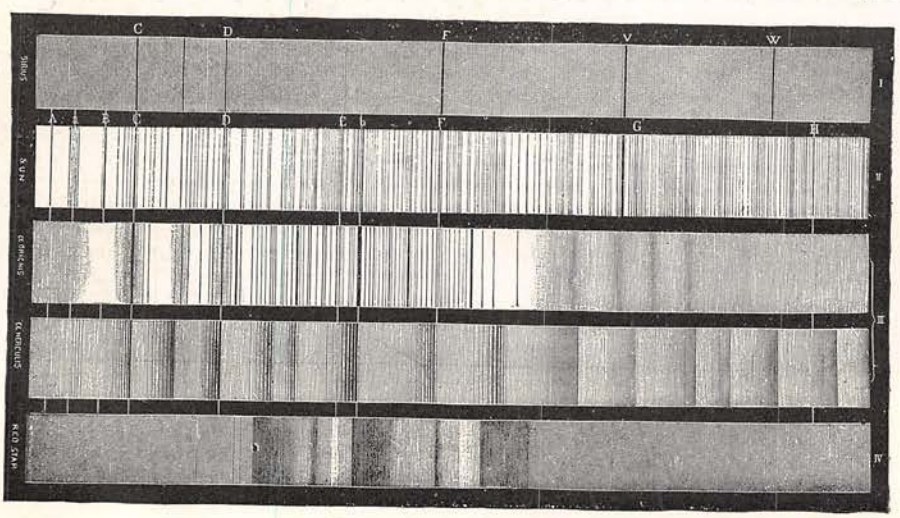
Margaret J. Preston.

THE STARS.

THE NEW ASTRONOMY.

IN the South Kensington Museum there is, as everybody knows, an immense collection of objects, appealing to all tastes and all classes, and we find there at the same time people belonging to the wealthy and cultivated part of society, lingering over the Louis Seize cabinets or the old majolica, and the artisan and his wife, studying the statements as to the relative economy of baking-powders, or admiring Tippoo Saib's wooden tiger.

There is one shelf, however, which seems to have some attraction common to all social grades, for its contents appear to be of equal interest to the peer and the costermonger. It is the representation of a *man* resolved into his chemical elements, or rather, an exhibition of the materials of which the human body is composed. There is a definite amount of water, for instance, in our blood and tissues, and there on the shelf are just so many gallons of water in a large vessel. Another jar shows the exact quantity of carbon in us; smaller bottles contain our iron and our phosphorus in just proportion, while others exhibit still other constituents of the body, and the whole reposes on the shelf, as if ready for the



TYPES OF STELLAR SPECTRA.

THE MILKY WAY. (FROM A STUDY BY E. L. TROUVELOT, BY PERMISSION OF CHARLES SCRIBNER'S SONS.)

coming of a new Frankenstein, to re-create the original man and make him walk about again as we do. The little vials that contain the different elements which we all bear about in small proportions are more numerous, and they suggest, not merely the complexity of our constitutions, but the identity of our elements with those we have found by the spectroscope, not alone in the sun, but even in the distant stars and nebulæ, for this wonderful instrument of the New Astronomy can find the traces of poison in a stomach or analyze a star, and its conclusions lead us to think that the ancients were nearly right when they called man a microcosm, or little universe. We have literally within our own bodies samples of the most important elements of which the great universe without is composed, and you and I are not only like each other, and brothers in humanity, but children of the sun and stars in a more literal sense, having bodies actually made in large part of the same things that make Sirius and Aldebaran. They and we are near relatives.

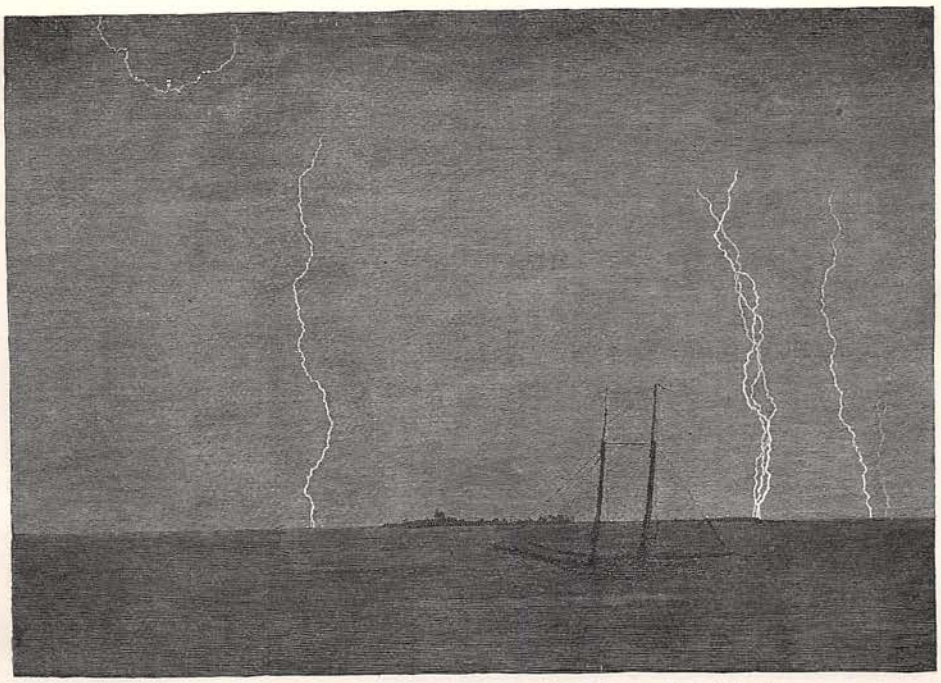
But if near in kind, we are distant relatives in another way, for the sun, whose remoteness we have elsewhere tried to give an idea of, is comparatively close at hand; quite at hand,

A FALLING MAN.

one may say, for if his distance, which we have found so enormous, be represented by that of a man standing so close beside us that our hand may rest on his shoulder, to obtain the proportionate distance of one of the *nearest* stars, like Sirius, for instance, we should need to send the man over a hundred miles away. It is probably impossible to give to any one an adequate idea of the extent of the sidereal universe; but it certainly is specially hard for the reader who has just realized with difficulty the actual immensity of the distance of the sun, and who is next told that this distance is literally a physical point as seen from the nearest star. The jaded imagination can be spurred to no higher flight, and the facts and the enormous numbers that convey them will not be comprehended.

Look down at one of the nests of those smallest ants, which are made in our paths. To these little people, we may suppose, the other side of the gravel walk is the other side of the world, and the ant who has been as far as the gate, a greater traveler than a man who comes back from the Indies. It is very hard to think not only of ourselves as relatively far smaller than such insects, but that, less than such an ant-hill is to the whole landscape, is our solar system itself, in comparison with the new prospect before us — yet so it is.

All greatness and littleness are relative. When the traveler from the great star Sirius (where, according to the author of "Micromegas," all the inhabitants are proportionately tall and proportionately long-lived) discovered our own little solar system, and lighted on what we call the majestic planet Saturn, he was naturally astonished at the pettiness of everything compared with the world he had left. That the Saturnian inhabitants were in his eyes a race of mere dwarfs (they were only a mile high, instead of twenty-four miles like himself) did not make them contemptible to his philosophic mind, for he reflected that such little creatures might still think and reason; but when he learned that these puny beings were also correspondingly short-lived, and passed but fifteen thousand years between the cradle and the grave, he could not but agree that this was like dying as soon as one was born, that their life was but a span, and their globe an atom. Yet it seems that when one of these very Saturnian dwarfs came afterward with him to our own little ball, and by the aid of a microscope discovered certain animalculæ on its surface, and even held converse with two of them, he could not in turn make up his own mind that intelligence could inhere in such invisible insects, till one of them (it was an astronomer with his sextant) measured his height to an inch, and the other, a divine, expounded to him the theology of some of these mites, according to which all the heavenly host,



A FLASH OF LIGHTNING. (FROM A PHOTOGRAPH BY DR. H. G. PIFFARD.)

including Saturn and Sirius itself, were created for *them*.

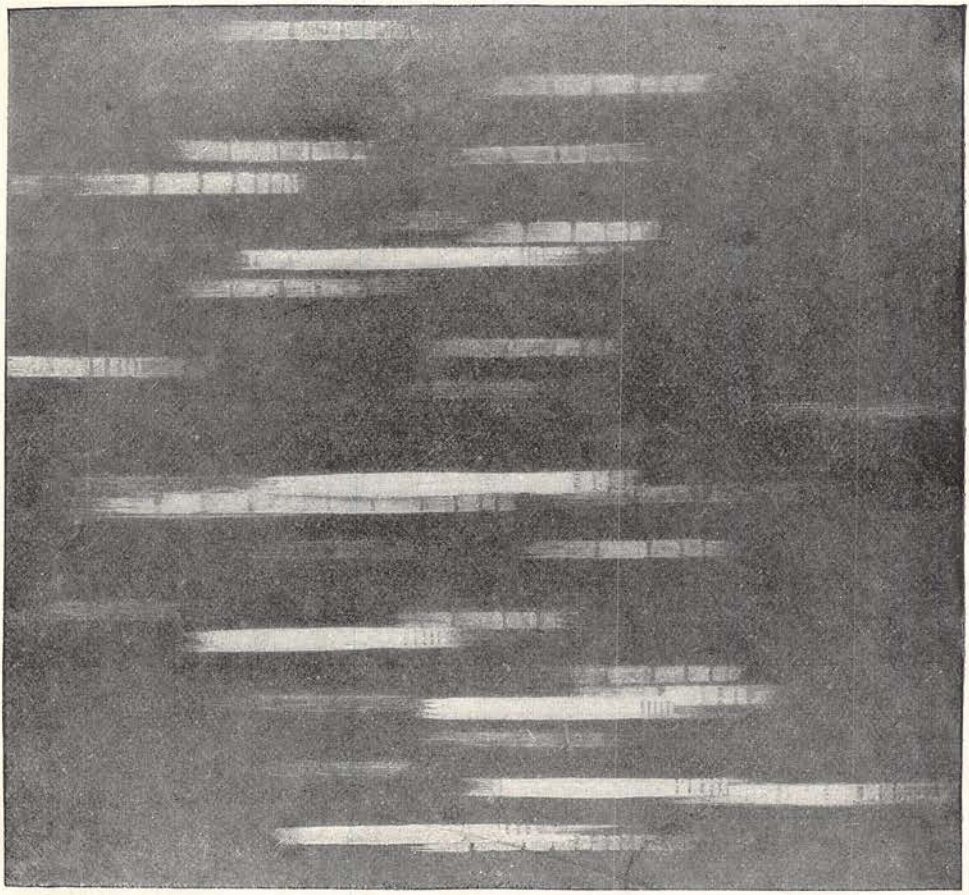
Do not let us hold this parable as out of place here, for what use is it to write down a long series of figures expressing the magnitude of other worlds, if it leave us with the old sense of the importance to creation of our own, and what use to describe their infinite number to a human mite who reads and remains of the opinion that *he* is the object they were all created for?

Above us are millions of suns like ours. The Milky Way (shown on page 587) spreads among them, vague and all-surrounding, as a type of the infinities yet unexplored, and of the world of nebulæ of which we still know so little. Let us say at once that it is impossible here to undertake the description of the discoveries of the New Astronomy in this region, for we can scarcely indicate the headings of the chapters which would need to be written to describe what is most important.

The first of these chapters (if we treated our subjects in the order of distance) would be one on space itself, and our changed ideas of the void which separates us from the stars. Of this we will only say in passing, that the old term "the temperature of space" has been nearly abrogated, for while it used to be supposed that more than half of the heat which warmed the earth came from this mysterious "space" or from the stars, it is now recognized that the earth is principally warmed only by the sun. Of the contents of the region between the earth and the stars, we have, it must be admitted, still little but conjecture, though perhaps that conjecture turns more than it used to the idea that the void is not a real void, but that it is occupied by something which, if highly attenuated, is none the less matter; and something other and more than the mere metaphysical conception of a vehicle to transmit light to us.

Of the stars themselves, we should need another chapter to tell what has been newly learned as to their color and light, even by the old methods, that is, by the eye and the telescope alone; but if we cannot dwell on this, we must at least refer, however inadequately, to what American astronomers are doing in this department of the New Astronomy, and first in the photometry of the stars, which has assumed a new importance of late years, owing to the labors carried on in this department at Cambridge.

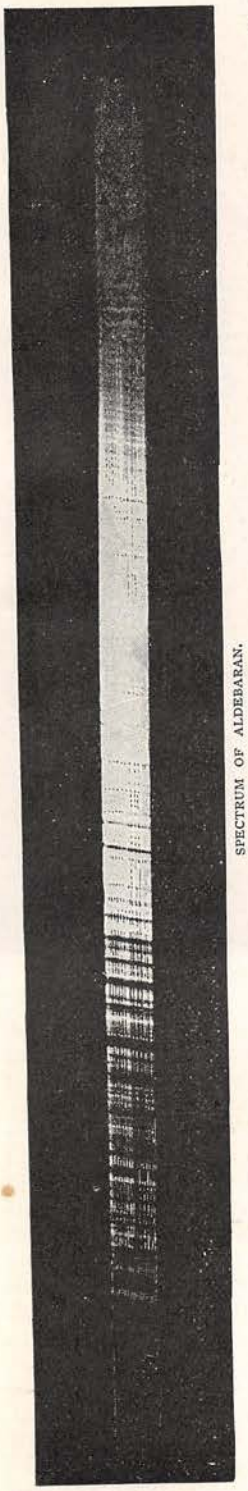
That one star differs from another star in glory we have long heard, but our knowledge of physical things depends largely on our ability to answer the question, "how much?" and the value of this new work lies in the accuracy and fullness of its measures, for in this case the whole heavens visible from Cambridge to near the southern horizon have been surveyed, and the brightness of every



SPECTRA OF STARS IN PLEIADES.

naked-eye star repeatedly measured, so that all future changes can be noted. This great work has taxed the resources of a great observatory, and its results are only to be adequately valued by other astronomers; but Professor Pickering's own investigations on variable stars have a more popular interest. It is surely an amazing fact that suns as large or larger than our own should seem to dwindle almost to extinction, and regain their light within a few days or even hours; yet the fact has long been known, while the cause has remained a mystery. A mystery, in most cases, it remains still, but in some we have begun to get knowledge, as in the well-known instance of Algol, the star in the head of Medusa. Here it has always been thought probable that the change was due to something coming between us and the star; but it is on this very account that the new investigation is more interesting, as showing how much can be done on an old subject by fresh reasoning alone, and how much valuable ore may lie in material which has already been sifted. The discussion of the subject by Professor Pickering, apart from its elevated aim, has if only in its acute analysis only the interest belonging to a story where the reader first sees a number of possible clews to some mystery, and then the gradual setting aside, one by one, of those which are only loose ends, and the recognition of the real ones which lead to the successful solution. The skill of the novelist, however, is more apparent than real, since the riddle he solves for us is one he has himself constructed, while here the enigma is of nature's propounding; and if the solution alone were given us, the means by which it is reached would indeed seem to be inexplicable.

This is especially so when we remember what a point there is to work on, for the whole system reasoned about, though it may be larger than our own, is at such a distance that it appears, literally and exactly, far smaller to the eye than the point of the finest sewing-needle; and it is a course of accurate reasoning, and reasoning alone, on the character of the observed changing brightness of this point,



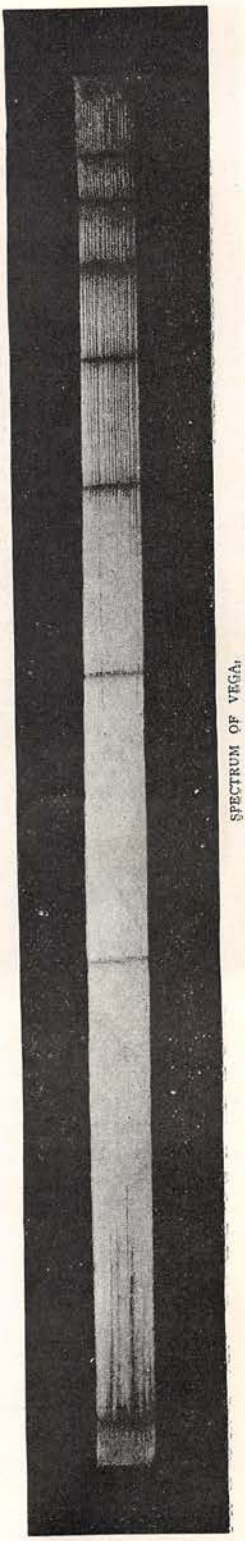
SPECTRUM OF ALDEBARAN.

which has not only shown the existence of some great dark satellite, but indicated its size, its distance from its sun, its time of revolution, the inclination of its orbit, and still more. The existence of dark invisible bodies in space, then, is in one case, at least, demonstrated, and in this instance the dark body is of enormous size, for, to illustrate by our own solar system, we should probably have to represent it in imagination by a planet or swarm of planetoids hundreds of times the size of Jupiter, and (it may be added) whirling around the sun at less than a tenth the distance of Mercury.

Of a wholly different class of variables are those which have till lately only been known at intervals of centuries, like that new star Tycho saw in 1572. I infer from numerous inquiries that there is such a prevalent popular notion that the "Star of Bethlehem" may be expected to show itself again at about the present time, that perhaps I may be excused for answering these questions in the present connection.

In the first place, the idea is not a new, but a very old, one, going back to the time of Tycho himself, who disputed the alleged identity of his star with that which appeared to the shepherds at the Nativity. The evidence relied on is, that bright stars are said to have appeared in this constellation repeatedly at intervals of from three hundred and eight to three hundred and nineteen years (though even this is uncertain); and as the mean of these numbers is about three hundred and fourteen, which again is about one-fifth of 1572 (the then number of years from the birth of Christ), it has been suggested, in support of the old notion, that the Star of Bethlehem might have been a variable, shining out every three hundred and fourteen or three hundred and fifteen years; whose fifth return would fall in with the appearance that Tycho saw, and whose *sixth* return would come in 1886 or 1887. This is all there is about it, and there is nothing like evidence, either that this was the star seen by the Wise Men, or that it is to be seen again by us. On the other hand, nothing in our knowledge, or rather in our ignorance, authorizes us to say positively it cannot come again, and it may be stated for the benefit of those who like to believe in its speedy return, that if it does come, it will make its appearance some night in the northern constellation of Cassiopeia's chair, the position originally determined by Tycho at its last appearance, being twenty-eight degrees and thirteen minutes from the pole, and twenty-six minutes in right ascension.

We were speaking of these new stars as having till lately only appeared at intervals of



SPECTRUM OF VEGA.

GREAT NEBULA IN ORION. (FROM A PHOTOGRAPH BY A. A. COMMON, F. R. S.)

centuries; but it is not to be inferred that if they now appear oftener it is because there are more of them. The reason is, that there are more persons looking for them, and the fact is recognized that, if we have observers enough and look closely enough, the appearance of "new stars" is not so very rare a phenomenon. Every one at all interested in such matters remembers that in 1866 a new star broke out in the Northern Crown so suddenly that it was shining as bright as the Polar Star, where six hours before there had been nothing visible to the eye. Now all stars are not as large as our sun, though some are much larger; but there are circumstances which make it improbable that this was a small or near object, and it is well remembered how the spectroscope showed the presence of abnormal amounts of incandescent hydrogen, the material which is perhaps the most widely diffused in the universe (and which is plentiful, too, in our own bodies), so that there was some countenance to the popular notion that this was a world in flames. We were, at any rate, witnessing a catastrophe which no earthly experience can give us a notion of, in a field of action so remote that the flash of light which brought the news was unknown years on the way, so that all this — strange but now familiar thought — occurred long before we *saw* it happen. The star faded in a few days to invisibility to the naked eye, though not to the telescope; and, in fact, all these phenomena at present appear to be rather enormous and sudden enlargements of the light of existing bodies than the creation of absolutely new ones; while of these "new stars," the examples may almost be said to be now growing numerous, two having appeared in the last two years.

Not to enlarge, then, on this chapter of photometry, let us add, in reference to another department of stellar astronomical work, that the recognized master in the study of double stars the world over is not an astronomer by profession, at the head of some national observatory in Berlin or Paris, but a stenographer in the Chicago law-courts, Mr. W. S. Burnham, who, after his day's duties, by nightly labor, prolonged for years with the small means at an amateur's command, has perhaps added more to our knowledge of his special subject in ten years than all other living astronomers.

We have only here alluded to the spectroscope in its application to stellar research, and we cannot now do more than to note the mere headlines of the chapters that should be written on it.

It is the memorable fact, that after reaching across the immeasurable distances, we find that the stars are like *us;* like in their ultimate elements to those found in our own sun, our own earth, our own bodies. Any fuller view of the subject than that which we here only indicate would commence with the evidence of this truth, which is perhaps on the whole the most momentous our science has brought us, and with which no familiarity should lessen our wonder, or our sense of its deep and permanent significance.

Next, perhaps, we should understand that, invading the province of the Old Astronomy, the spectroscope now tells us of the motions of these stars, which we cannot see move; motions in what we have always called the "fixed" stars, to signify a state of fixity to the human eye which is such that to it at the close of the nineteenth century they remain in the same relative positions that they occupied when that eye first looked on them, in some period long before the count of centuries began.

In perhaps the earliest and most enduring work of man's hands, the great pyramid of Egypt, is a long straight shaft, cut slopingly through the solid stone, and pointing, like a telescope, to the heavens near the pole. If we look through it now we see — nothing; but when it was built it pointed to a particular star which is no longer there. That pyramid was built when the savages of Britain saw the Southern Cross at night, and the same slow change in the direction of the earth's axis itself that in thousands of years has borne that constellation to southern skies has carried the stone tube away from the star that it once pointed at. The actual motion of the star itself, relatively to our system, is slower yet — so inconceivably slow that we can hardly realize it by comparison with the duration of the longest periods of human history. The stone tube was pointed at the star by the old Egyptians, but "Egypt itself is now become the land of obliviousness, and doteth. Her ancient civility is gone, and her glory hath vanished as a phantasma. She poreth not upon the heavens, astronomy is dead unto her, and knowledge maketh other cycles. Canopus is afar off, Memnon resoundeth not to the Sun, and Nilus heareth strange voices." In all this lapse of ages the star's own motion could not have so much as carried it across the mouth of the narrow tube. Yet a motion to or from us of this degree, so slow that the unaided eye could not see it in thousands of years of watching, the spectroscope first, efficiently in the hands of the English astronomer, Dr. Huggins, and later in those of Professor Young of Princeton, not only reveals at a look, but tells us the amount and direction of, in a way that is as strange and unexpected, in the view of our knowledge a generation ago, as its revelation of the essential composition of the bodies themselves.

Again, in showing us this composition, it has also shown us more, for it has enabled us to form a conjecture as to the relative ages of the stars and suns; and this work of classifying them, not only according to their brightness, but each after his kind, we may observe was begun by a countryman of our own, Mr. Rutherfurd, who seems to have been among the first after Fraunhofer to apply the newly invented instrument to the stars, and quite the first to recognize that these were, broadly speaking, divisible into a few leading types, depending not on their size but on their essential nature. After him Secchi (to whom the first conception is often wrongly attributed) developed it, and gave four main classes into which the stars are in this way divisible, a classification which has been much extended by others; while the first carefully delineated spectra were those of Dr. Huggins, who has done so much for all departments of our science that in a fuller account his name would reappear in every chapter of this New Astronomy, and than whom there is no more eminent living example of its study. Owing to their feeble light, years were needed when he began his work to depict completely so full a single spectrum as that he gives of Aldebaran, though he has lived to see stellar spectrum photography, whose use he first made familiar, producing in its newest development, which we give here, the same result in almost as many minutes. Before we present this latest achievement of celestial photography, let us employ the old method of an engraving made from eye-drawings once more, to illustrate on page 586 the distinct character of these spectra, and their meaning. In the telespectroscope, the star is drawn out into

a band of colored light, but here we note only in black and white the lines which are seen crossing it, the red end in these drawings being at the left, and the violet at the right; and we may observe of this illustration, that though it may be criticised by the professional student, and though it lack to the general reader the attraction of color, or of beautiful form, it is yet full of interest to any one who wishes to learn the meaning of the message the star's light can be made to yield through the spectroscope, and to know how significant the differences are it indicates between one star and another, where all look so alike to the eye. First is the spectrum of a typical white or blue-white star, Sirius, the very brightest star in the sky, and which we all know. The brighter part of the spectrum is a nearly continuous ribbon of color, crossed by conspicuous, broad, dark lines, exactly corresponding in place to narrower ones in our sun, and due principally to hydrogen. Iron and magnesium are also indicated in this class, but by too fine lines to be here shown.

Sirius, as will be presently seen, belongs to the division of stars whose spectrum indicates a very high temperature, and in this case, as in what follows, we may remark (to use in part Mr. Lockyer's words) that one of the most important distinctions between the stars in the heavens is one not depending upon their mass or upon anything of that kind, but upon conditions which make their spectra differ just in the way that in our laboratories the spectrum of one and the same body will differ at different temperatures.

What these absolutely are in the case of the stars, we may not know, but placing them in their most probable relative order, we have taken as an instance of the second class or lower-temperature stage our own sun. The impossibility of giving a just notion of its real complexity may be understood, when we state that in the recent magnificent photographs by Professor Rowland, a part of this spectrum alone occupies something like fifty times the space here given to the whole, so that, crowded with lines as this appears, scarcely one in fifty of those actually visible can be given in it. Without trying to understand all these now, let us notice only the identity of two or three of its principle elements with those found in other stars, as shown by the corresponding identity of some leading lines. Thus, C and F (with others) are known to be caused by hydrogen; D, by sodium; *b*, by magnesium; while fainter lines are given by iron and by other substances. These elements can be traced by their lines in most of the different star-spectra on this plate, and all those named are constituents of our own frames.

The hydrogen lines are not quite accurately shown in the plate from which our engraving is made; those in Sirius, for instance, being really wider by comparison than they are here given, and we may observe in this connection, that by the particular appearance such lines wear in the spectrum itself, we can obtain some notion of the *mass* of a star, as well as of its chemical constitution. We can compare the essential characteristics of such bodies then without reference to their apparent size, or as though they were all equally remote; and it is a striking thought that when we thus rise to an impartial contemplation of the whole stellar universe, our sun, whose least ray makes the whole host of stars disappear, is found to be not only itself a star, but by comparison a small one — one at least which is more probably below than above the average individual of its class, while some, such as Sirius, are not impossibly hundreds of times its size.

Then comes a third class, such as is shown in the spectrum of the brightest star in Orion, looking still a little like that of our sun, but yet more distinctively in that of the brightest star in Hercules, looking like a columnar or fluted structure, and concerning which the observations of Lockyer and others create the strong presumption, not to say certainty, that we have here a lower temperature still. Antares and other reddish stars belong to this division, which in the very red stars passes into the fourth type; and there are more classes and subclasses without end, but we invite here attention particularly to the first three, much as we might present a child, an adult, and an old man, as types of the stages of human existence without meaning to deny that there are any number of ages between. We can even say that this may be something more than a mere figure of speech, and that a succession in age is not improbably pointed at in these types.

We may have considered — perhaps not without a sort of awe at the vastness of the retrospect — the past life of the worlds of our own system, from our own globe of fluid fire as we see it by analogy in the past, through the stages of planetary life to the actual condition of our present green earth and on to the stillness of the moon. Yet the life history of our sun, we can hardly but admit, is indefinitely longer than this. We feel, rather than comprehend, the vastness of the period that separates our civilization from the early life of the world; but what is this to the age of the sun, which has looked on and seen its planetary children grow? Yet if we admit this temperature classification of the stars, we are not far from admitting that the spectroscope is now pointing out the stages in the life of suns themselves; suns just beginning their life of

almost infinite years; suns in the middle of their course; suns which are growing old and casting feebler beams,— all these and many more it brings before us.

Another division of our subject would, with more space, include a fuller account of that strange and most interesting development of photography which is going on even while we write, and this is so new and so important that we must try to give some hint of it even in this brief summary, for even since the first numbers of this series were written, great advances have taken place in its application to celestial objects.

Most of us have vague ideas about small portions of time; so much so, that it is rather surprising to find to how many intelligent people a second, as seen on the clock face, is its least conceivable interval. Yet a second has not only a beginning, middle, and end, as much as a year has, but can, in thought, at least, be divided into just as many numbered parts as a year can. Without entering on a disquisition about this, let us try to show by some familiar thing that we can, at any rate, not only divide a second in imagination into, let us say, a hundred parts, but that we can observe distinctly what is happening in such a short time, and make a picture of it — a picture which shall be begun and completed while this hundredth of a second lasts.

Every one has fallen through at least some such a little distance as comes in jumping from a chair to the floor, and most of us, it is safe to say, have a familiar impression of the fact that it takes, at any rate, less than a second in such a case from the time the foot leaves its first support till it touches the ground. Plainly, however large or small the fall may be, each fraction of an inch of it must be passed through in succession, and if we suppose the space to be divided, for instance, into a hundred parts, we must divide in thought the second into at least as many, since each little successive space was traversed in its own little interval of time, and the whole together did not make a second. We can even, as a matter of fact, very easily calculate the time that it will take anything which has already fallen, let us say, one foot to fall an inch more; and we find this in the supposed instance to be almost exactly one one-hundredth of a second. On page 588 is a reproduction of a photograph from nature of a man falling freely through the air. He has dropped from the grasp of the man above him, and has already fallen through some small distance — a foot or so. If we suppose it to be a foot, since we can see that the man's features are not blurred, as they would undoubtedly have been had he moved even much less than an inch while this picture was being taken, it follows from what has been said, that the taking of the whole picture — landscape, spectators, and all — occupied not *over* one one-hundredth of a second.

We have given this view of the falling man because rightly understood it thus carries internal evidence of the limit of time in which it could have been made; and this will serve as an introduction to another picture where probably no one will dispute that the time was still shorter, but where we cannot give the same kind of evidence of the fact.

"Quick as lightning" is our common simile for anything occupying, to ordinary sense, no time at all. Exact measurements show that the electric spark does occupy a time, which is almost inconceivably small, and of which we can only say here that the one one-hundredth of a second we have just been considering is a long period by comparison with the duration of the brightest portion of the light.

On page 589 we have the photograph of a flash of lightning (which proves to be several simultaneous flashes) taken last July from a point on the Connecticut coast, and showing not only the vivid zigzag streaks of the lightning itself, but something of the distant sea view, and the masts of the coast survey schooner *Palinurus* in the foreground, relieved against the sky. We are here concerned with this interesting autograph of the lightning only as an illustration of our subject and as proving the almost infinite sensitiveness of the recent photographic processes, for there seems to be no limit to the briefness of time in which these can so act in some degree, whether the light be bright or faint, and no known limit to the briefness of time required for them to act *effectively* if the light be bright enough.

What has just preceded will now help us to understand how it is that photography also succeeds so well in the incomparably fainter objects we are about to consider and which have been produced not by short but by long exposures. We have just seen how sensitive the modern plate is, and we are next to notice a new and very important point in which photographic action in general differs remarkably from that of the eye. Seeing may be described, not wholly inaptly, as the recognition of a series of brief successive photographs, taken by the optic lens on the retina, but the important difference between seeing and photographing which we now ask attention to is this: When the eye looks at a faint object, such as the spectrum of a star or at the still fainter nebula, this, as we know, appears no brighter at the end of half an hour

than at the end of the first half-second. In other words, after a brief fraction of a second, the visual effect does not sensibly accumulate. But in the action of the photograph, on the contrary, the effect *does* accumulate, and in the case of a weak light accumulates indefinitely. It is owing to this precious property, that supposing (for illustration merely) the lightning flash to have occupied the one-thousandth part of a second in impressing itself on the plate: to get a nearly similar effect from a continuous light one thousand times weaker, we have only to expose it a thousand times as long, that is, for one second, while from a light a million times weaker, we should get the same result by exposing it a million times as long, that is, for a thousand seconds.

And now that we come to the stars, whose spectra occupy minutes in taking, what we just considered will help us to understand how we can advantageously thus pass from a thousandth of a second or less to one thousand seconds or even more, and how we can even,— given time enough,— conceivably, be able to photograph what the eye *cannot see at all.*

We have on page 590 a photograph quite recently taken at Cambridge from a group of stars (the Pleiades) passing by the telescope. Every star is caught as it goes, and presented, not in its ordinary appearance to the eye, but by its spectrum. There is a general resemblance in these spectra from the same cluster; while in other cases the spectra are of all types and kinds, the essential distinction between individuals alike to the eye being more strikingly shown, as stars apparently far away from one another are seen to have a common nature, and stars looking close together (but which may be merely in line, and really far apart) have often no resemblance; and so the whole procession passes through the field of view, each individual leaving its own description. This self-description will be better seen in the remarkable photographs of the spectra of Vega and Aldebaran which are reproduced on page 591 from the originals by a process independent of the graver. They were obtained on the night of November 9th, 1886, at Cambridge, as a part of the work pursued by Professor Pickering, with means which have been given from fitting hands thus to form a memorial of the late Dr. Henry Draper. We are obliged to the source indicated, then, for the ability to show the reader here the latest, and as yet inedited, results in this direction, and they are such as fully to justify the remark made above, that minutes by this new process take the place of years of work by the most skillful astronomer's eye and hand.

The spectrum of Vega (Alpha Lyrae) is marked only by a few strong lines, due chiefly to hydrogen, because these are all there are to be seen in a star of its class. Aldebaran (the bright star in Taurus), on the contrary, here announces itself as belonging to the family of our own sun, a probably later type, and distinguished by solar-like lines in its spectrum, which may be counted in the original photograph to the number of over two hundred. There is necessarily some loss in the printed reproduction, but is it not a wonderful thing to be able to look up, as the reader may do this February night, to Aldebaran in the western sky, and then down upon the page before us, knowing that that remote, trembling speck of light has by one of the latest developments of the New Astronomy been made, without the intervention of the graver's hand, to write its own autograph record on a page of THE CENTURY before him?

In the department of nebular astronomy, photography has worked an equal change. The writer well remembers the weeks he has himself spent in drawing or attempting to draw nebulæ; things often so ghost-like as to disappear from view every time the eye turned from the white paper, and only to be seen again when it had recovered its sensitiveness by gazing into the darkness. The labors of weeks were literally only represented by what looked like a stain on the paper, and no two observers, however careful, could be sure that the change between two drawings of a nebula at different dates was due to an alteration in the thing itself, or in the eye or hand of the observer, though unfortunately for the same reason it is impossible fully to render the nebulous effect of the photograph in engraving. We cannot with our best efforts do, then, full justice to the admirable one of Orion on page 592 which we owe to the particular kindness of Mr. Common, of Ealing, England, whose work in this field is as yet unequaled. The original enlargement measures nearly two square feet in area, with fine definition. It is taken by thirty-nine minutes' exposure, and its character can only be indicated here, for it is not too much to say here, too, of this original, that as many years of the life of the most skilled artist could not produce so trustworthy a record of this wonder.

The writer remembers the interest with which he heard Dr. Draper, not long before his lamented death, speak of the almost incredible sensitiveness of these most recent photographic processes, and his belief that we were fast approaching the time when we should photograph what we could not even see. That time has now arrived. At Cambridge, in Massachusetts, and at the Paris Observatory, by taking advantage of the cumulative action we have referred to, and by long exposures, photo-

graphs have recently been taken showing stars absolutely invisible to the telescope, and enabling us to discover faint nebulæ whose previous existence had not been suspected; and when we consider that an hour's exposure of a plate now not only secures a fuller star-chart than years of an astronomer's labor, but a more exact one; that the art is every month advancing perceptibly over the last, and that it is already, as we may say, not only making pictures of what we see, but of what we cannot see, even with the telescope,— we have before us a prospect whose possibilities no further words are needed to suggest.

We have now not described, but only mentioned, some division of the labors of the New Astronomy in its photometric, spectroscopic, and photographic stellar researches, on each of which as many books, rather than chapters, might be written, to give only what is novel and of current interest. But these are themselves but a part of the modern work that has overturned or modified almost every conception about the stellar universe which was familiar to the last generation, or which perhaps we were taught in our own youth.

IN considering the results to be drawn from this glance we have taken at some facts of modern observation, if it be asked, not only what the facts are, but what lessons the facts themselves have to teach, there is more than one answer, for the moral of a story depends on the one who draws it, and we may look on our story of the heavens from the point of view either of our own importance or of our own insignificance. In the one case, we behold the universe as a sort of reflex of our own selves, mirroring in vast proportions of time and space our own destiny; and even from this standpoint, one of the lessons of our subject is surely that there is no permanence in any created thing. When primitive man learned that with lapsing years the oak withered and the very rock decayed, more slowly but as surely as himself, he looked up to the stars as the very types of contrast to the change he shared, and fondly deemed them eternal; but now we have found change there, and that probably the star clusters and the nebulæ, even if clouds of suns and worlds, are fixed only by comparison with our own brief years, and, tried by the terms of their own long existence, are fleeting like ourselves.

"We have often witnessed the formation of a cloud in a serene sky. A hazy point barely perceptible — a little wreath of mist increases in volume and becomes darker and denser, until it obscures a large portion of the heavens. It throws itself into fantastic shapes, it gathers a glory from the sun, is borne onward by the wind, and as it gradually came, so, perhaps, it gradually disappears, melting away in the untroubled air. But the universe is nothing more than such a cloud — a cloud of suns and worlds. Supremely grand though it may seem to us, to the infinite and eternal intellect it is no more than a fleeting mist. If there be a succession of worlds in infinite space, there is also a succession of worlds in infinite time. As one after another cloud replaces clouds in the skies, so this starry system, the universe, is the successor of countless others that have preceded it — the predecessor of countless others that will follow."

These impressions are strengthened rather than weakened when we come back from the outer universe to our own little solar system, for every process which we know tends to the dissipation, or rather the degradation, of heat, and seems to point, in our present knowledge, to the final decay and extinction of the light of the world. In the words of one of the most eminent living students of our subject, "The candle of the sun is burning down, and, as far as we can see, must at last reach the socket. Then will begin a total eclipse which will have no end."

Yet though it may well be that the fact itself here is true, it is possible that we draw the moral to it, unawares, from an unacknowledged satisfaction in the idea of the vastness of the funeral pyre provided for such beings as ourselves, and that it is pride, after all, which suggests the thought that when the sun of the human race sets, the universe will be left tenantless as a body from which the soul has fled. Can we not bring ourselves to admit that there may be something higher than man and more enduring than frail humanity in some sphere in which *our* universe, conditioned as it is, in space and time, is itself embraced, and so distrust the conclusions of man's reason where they seem to flatter his pride?

May we not receive even the teachings of science, as to the laws of nature, with the constant memory that all we know even from science itself depends on our very limited sensations, our very limited experience, and our still more limited power of conceiving anything for which this experience has not prepared us?

I HAVE read somewhere a story about a race of ephemeral insects who live but an hour. To those who are born in the early morning the sunrise is the time of youth. They die of old age while his beams are yet gathering force, and only their descendants live on to midday; while it is another race which sees the sun decline, from that which saw him rise. Imagine the sun about to set, and the whole nation of mites gathered under the shadow of some

mushroom (to them ancient as the sun itself) to hear what their wisest philosopher has to say of the gloomy prospect. If I remember aright, he first told them that, incredible as it might seem, there was not only a time in the world's youth when the mushroom itself was young, but that the sun in those early ages was in the eastern, not in the western, sky. Since then, he explained, the eyes of scientific ephemera had followed it, and established by induction from vast experience the great law of nature, that it moved only westward; and he showed that since it was now nearing the western horizon, science herself pointed to the conclusion that it was about to disappear forever, together with the great race of ephemera for whom it was created.

What his hearers thought of this discourse I do not remember, but I have heard that the sun rose again the next morning.

S. P. Langley.

RECENT DISCOVERIES OF WORKS OF ART IN ROME.

BY THE DIRECTOR OF THE NEW MUSEO URBANO.

IN a manuscript volume of the Vatican Library, belonging to the Syriac collection, and numbered one hundred and forty-five, a short description of Rome has been found, written A. D. 546, by Zacharias, a Byzantine historian and bishop of Mitylene in the island of Lesbos. From his account we gather that, towards the middle of the sixth century of our era, there were in Rome *eighty* statues of gilt bronze representing gods, *three thousand seven hundred and eighty-five* bronze statues of miscellaneous subjects, and *twenty-five* bronze statues which according to the tradition had been removed from Jerusalem by Vespasian; in total, three thousand eight hundred and ninety works of art in bronze, exhibited in public places. Of this immense and invaluable collection a particle only has come down to us; in fact, the list of antique bronzes in modern Rome is so short that, as regards number, the contents of our museums cannot be compared favorably with the contents of the National Museum in Naples. Our list comprises, first of all, the Capitoline collection, namely, the "Bronze Wolf," the equestrian statue of M. Aurelius, the colossal head of Domitian, the "Camillus" or sacrificing youth, the "Boy Extracting a Thorn," and the "Hercules" from the Forum Boarium. Many errors connected with the origin and the discovery of these famous bronzes have been circulated, and are still believed by many. The equestrian statue is said to have been found between the Lateran and the basilica of S. Croce in Gerusalemme, in a vineyard adjoining the "Scala Santa"; the "She-wolf," to have been found under the N. W. spur of the Palatine hill, near the so-called "Arco degli argentieri" at S. Giorgio in Velabro; the colossal head of Domitian, to have been found in 1487 near the basilica of Constantine on the "Sacra Via," and so on. The truth is that these celebrated works have *never* been lost and rediscovered; and that, from the fall of the empire downwards, they have been kept together and preserved in and around the Pope's palace at the Lateran, until Sixtus IV. and Paul III. caused them to be removed to the Capitol.

Of the equestrian statue of M. Aurelius we have accounts since the tenth century. In the year 966, Peter, prefect of Rome, was executed for rebellion against Pope John XIII., being hung by the hair from this horse; and at its feet was flung the corpse of the Antipope Boniface, son of Ferruccio, in the year 974. We hear again of the group in 1347, during the festivities which followed the election of Rienzi to the tribuneship, when, for nearly a whole day, wine was made to flow from one nostril of the horse, water from the other. This constant connection of the equestrian group with the Lateran, from immemorial time, makes us believe that it was never removed thither from the Forum, as commonly asserted, but that it must have belonged to the Lateran imperial residence since the time of Marcus Aurelius, who was born and educated in the house of the Annii close by.

As regards the "She-wolf," the positive evidence of its being kept at the Lateran dates from the beginning of the ninth century. Benedict, a monk from Mount Soracte who wrote a "Chronicon" in the tenth century, speaks of the institution of a supreme court of justice "in the Lateran palace, in the place called *the Wolf*, viz., the mother of the Romans." Trials and executions "at the Wolf" are recorded from time to time until 1450. Paolo di Liello speaks of two highwaymen, whose hands, cut by the executioner, were hung at the Wolf. It was removed to the Conservatori palace on the Capitol in 1473, together with the colossal head, and the "Camillus."

The antique bronzes in the Vatican Museum