received a strong impulse in a new direction; and no longer finding the grasp of her powers restricted to the weighing of suns and planets, and to the measuring of their distances, she now aspires to a loftier aim, and hopes she is henceforth permitted by the Supreme Wisdom to understand some little of the processes from whence are elaborated the heat and the light of the sun, and what are the sources of even those paler fires which come spangling to us from the more distant stars.

The means by which this unexpected accession to our knowledge has been obtained, the long train of ingenious experiments (those questionings of Nature) and the logical deductions therefrom, which enable us to say with undoubting confidence, "In yonder star there exists iron at a burning heat; in another, there is incandescent vapour of lime, in almost all of them there are strong evidences of the existence of magnesia and salt, and the recent sudden outburst in the remarkable star of which we have spoken, was owing, in part at least, to the sudden combustion of *hydrogen gas*;" these things—we may almost call them wonderful things—we shall now proceed to lay before the reader.

In so doing, we fear we shall of necessity make a serious call upon his attention; but, in return, we promise him a rich reward for his exercise of patience. On the other hand, out of hundreds of thousands who will read these lines, there are probably some few who are as familiar as the writer with the simple but beautiful experiments we shall find it necessary to describe. But, even to these few, it can scarcely fail to be pleasant to travel once again over fields which, after all, present an inexhaustible variety; for there are visions of glory which never satiate, and there are truths the contemplation of whose comprehensive simplicity never palls. Among such, we venture to believe, are the laws of interaction which the Supreme Wisdom has impressed upon the material elements which are scattered in almost unbroken continuity through the universe of things.

We strongly advise the great majority of our readers to repeat the experiments we shall detail. With this end in view, we shall describe them simply and fully; and, moreover, we shall intentionally select such as require no great degree of skill, and involve no apparatus beyond such as is utterly inexpensive, and can now be procured in most houses and every village.

Let the reader, then, who desires to follow the train of our reasoning, take a piece of cardboard or stiff paper, about a foot or eighteen inches square; any colour is somewhat better than white, and it must be impervious to light. In the middle of this carefully cut a clean and even straight slit, parallel to one of the sides, not more than the twentieth of an inch wide, and about an inch and a half long. Fix this opaque paper, with wafers or otherwise, against a clean pane of glass in the window of a room, so that the thin slit shall be vertically upright, and at a height from the floor equal to the height of the observer's eye.

Now let him take a glass lustre off a chandelier. It will be best for him to select two or three, without veins, if such can fortunately be found, and much the better if the shape of the glass pendant happens to be, in section, an equilateral triangle; but in modern fashion these glass pendants for the most part have two or three faces perpendicular to each other. Through this rectangular edge vision is impossible, and the reader must avoid it. Now let him stand with his right eye exactly opposite to the slit, and if he can, through the slit, see a bright white cloud, that will be in his favour: his distance from the slit may be eight, or ten, or twelve feet, or even more. The lustre is to be held with one of its acute edges (not the rectangular edge, if it has one) vertically upright, and therefore parallel to the slit and close to his right eye, and with this eye he is to look through the left hand face of the glass. The direction also in which he must look must be towards the left, and, as it were, to some place on the left not quite so far from the slit as he is himself distant from it. He will then see the thin line of light from the slit spread out into a ribbon coloured with a variety of successive colors. The red colour will be nearest to the slit, on the right; and the blue will be farthest, on the left. To see this ribbon of coloured lights will require patience and some humouring of the glass lustre; but to the writer, who, nevertheless, bears in mind Columbus's egg, the whole actual manipulation at this moment has occupied less time than the description. The reader may consider himself fortunate if his own success requires twenty minutes to achieve. Probably he may see a variety of beautiful colored bands flitting about, but what he seeks is the ribbon, which proceeds from the light of the slit, and this he may distinguish from all the others by requesting an assistant to cover over the slit itself with a finger, from time to time.

When the experimenter has at last caught the sight of this beautiful coloured ribbon, or *spectrum*, as we shall now call it, he will find that, as he humors the glass (always holding its edge vertical) the spectrum itself will greatly vary in length and in its distance to the left of the slit; he must then so place the glass as to obtain the shortest spectrum he can, and then he must gradually open it out a little. If he has succeeded, and unless the glass be very uneven and full of veins, he will now see something not very dissimilar to the following:—At the right edge of the slit, a *red* color, a little way to the left it becomes *orange*, then a slight *yellow*, and then *green*, and a little to the left of the centre of the slit the colour is *blue*.

But what he is especially to look for (and what, in fact, is the object of the whole experiment), is the presence of one, or two, or three, or four, *black vertical lines*, between the colors. The writer himself, after a careless experiment like the one described, at this moment, on a dull day, sees two lines. As we have already said, the sight of these dark lines is the object of the search. They are not to be seen without patience: few philosophers are even now aware that they can be seen at all with so rude an apparatus; and when they were for the first time observed by our great countryman Dr. Wollaston, in 1802, they immortalized the discoverer.

Thirteen years after this, Fraunhofer, at Munich, by diminishing the breadth of the slit, by reflecting the direct sun-light through it from a looking-glass outside, by then using a prism of pure glass, and, lastly, by looking at the slit through the prism, not with the naked eye, but with a small telescope, observed and accurately measured the position of many hundreds of these lines. Without a telescope, if the reader possesses a tolerably good prism, he may readily see more lines than he can count. These lines have henceforth been called *Fraunhofer's Lines*. In fact of priority they are Wollaston's; but, unfortunately, our countryman did not attach due importance to the discovery, and he dropped the subject. Newton also, who a century before Wollaston first observed and studied the spectrum, lost the fame of his discovery from the simple fact of not putting the prism close to his eye.

Strange to say, these dark lines contain the key to the enigma of the material constitution of a star, and of our sun, and this is the reason why we have been thus particular in describing the easiest and most simple way of seeing a few of the most conspicuous among them.

The reader will probably have little or no difficulty in understanding that the coloured ribbon of light, called the spectrum, is nothing more than the thin line of light in the slit, *spread out*. He may conceive this line to resemble a bundle of innumerable coloured faggots, and that the glass or prism, through which they have passed, has arranged them all in an orderly manner. But then comes the question, *What is the significance of the dark interruption?* Do the colours which would otherwise properly belong to these dark spaces, not exist in the nature of things? Or do they not exist in *solar* light? Or do they in reality exist in light emanating from the sun, but subsequently have been absorbed somehow and somewhere? These are natural, inevitable questions occurring in relation to Fraunhofer's lines, but for upwards of fifty years these lines remained a perplexing mystery. The Sphinx had spoken, but Œdipus was not. Who could have perceived that the true solution lay in the existence of heated *terrestrial* substances dispersed in the sun and throughout the universe?

In 1832—that is just thirty years after their discovery by Wollaston—Dr. Brewster, by a very simple experiment (which we advise our readers to repeat, however roughly) demonstrated that those dark lines are produced by the absorption of those particular colored lines which, in the spectrum, they displace. Let the reader take a candle or a lamp, and in front of it let him place the narrow slit as before, and let him as before obtain the spectrum of the light; he will then see the same sort of beautiful coloured ribbon with which by this time he must be familiar; but he will see no dark lines, it will be continuous and uninterrupted.

But now let him procure a small uncut glass tumbler, in it let him place some small copper coin, and upon it let him, with all necessary caution, pour as much aquafortis (or nitric acid) as will just cover the coin, and immediately place a paper cover on the top, in order to confine the orange coloured vapours of nitrous gas which will presently fill the glass. This glass is to be quickly placed between the light and the slit, and the spectrum is now to be observed. It is no longer the bright uninterrupted spectrum which he had seen from the lamp before, but the coloured ribbon is crossed with a multitude of lines, greatly resembling, but not identical, with the lines discovered by Fraunhofer. The experiment, if well performed, is extremely beautiful, and one not likely to be forgotten. Here there is a demonstrated fact, that media do exist capable of absorbing light, and of producing a phenomenon closely resembling the dark lines in the solar spectrum.

But then comes the question, What is it that absorbs certain portions of the solar light? Is it something in the atmosphere of the sun, or something in the atmosphere of the earth? Thus the mystery became increased!

The next step in advance was taken by Professor Wheatstone, about three years after Brewster's discovery of the absorption of certain lights by certain coloured vapours. By a process of considerable difficulty he contrived to render the *vapours* of the metals incandescent; and then viewing the light emitted by these vapours through a slit and prism, as before, he found that the spectra did not consist of a continuous coloured ribbon of light, but simply of a few detached *bright coloured lines*. The incandescent vapours of no two metals gave precisely the same lines. In fact, so extremely definite was the spectrum of each metallic vapour, that Professor Wheatstone did not hesitate to say that by this method the presence of extremely minute portions of the metals could be detected with greater certainty than by any other known process.

The reader may easily try the experiment on a small scale for himself, by burning a little magnesium wire (now, thanks to the wide diffusion of scientific knowledge, so easily procured,) behind the slit, when he will at once recognize a peculiar spectrum of certain bright greenish lines. Or if he drop a little salt into the flames of a lamp or candle, he will immediately see a bright yellow line.

And further, if while he is viewing a good spectrum of the light from the candle, an assistant opens and shuts with some violence an old dusty book close to the light, he will probably see, for the moment, a vast number of bright-coloured lines suddenly start into existence throughout the spectrum. These lines arise from the vapourization and incandescence of a vast number of minute substances collected in the dust.

But these lines in the spectra of metallic vapours—and the same remark applies equally to incandescent *gases*, such as hydrogen, &c.,—are all *bright* lines, whereas those in the solar spectrum are *dark*. What, then, is the relation between the two?

And now came a variety of guesses; one might almost call them divinations of the truth. The annals of Science tell us that such divinations of truth beforehand not rarely precede the discovery of great, comprehensive, pregnant truths. They preceded the discovery of the Law of Gravitation; they preceded the discovery of oxygen: they preceded the discovery of electro-magnetism; and even now they seem to loom before the discovery of the yet unknown cause of gravitation itself. Newton divined the combustible nature of the diamond a century before Allen and Pepys succeeded in showing it was nothing more than pure crystalized carbon.

But what is it—we may ask—what is it which, as it were, causes coming and substantial discoveries so often to throw their shadows before them? Is it some single word, or some chance expression, which, as a winged seed falling from one master mind, is wafted, like a rumour, amongst other minds, until, at length, it finds a proper and kindred home, and then germinates and fructifies into the ripeness of some general truth? Or is it that the minds of men, after some unknown process, and in accordance with some magnificent pre-arrangement of the Great Eternal Mind, become, from time to time, by the interaction of circumstances, polarized, and when the tension becomes extreme, break forth at length into the force and light of discovery?

Be this as it may, it is certain, that Professor Stokes, in England; Balfour Stewart, in Scotland; M. Foucalt, in France; and M. Angatrim, in Sweden, all assigned a probable cause for portions, at least, of the