

It is a curious coincidence that while I was at work on *Drosera*, an almost identical research was being conducted in Germany. The experiment of Drs. Kellermann and von Raumer were described before the Phys. Med. Society of Erlangen in July, 1877, and the final results were communicated by Rees, of Erlangen, to the *Botanische Zeitung*, April 5, 1878.

The research was evidently conducted with extreme care, and it is very satisfactory to me to find that my results agree (speaking generally) with those of Kellermann and von Raumer. The plants used in their experiments were fed on aphides, and do not seem to have thriven quite so heartily as mine did on a meat diet. This appears from the following figures:—

	Kellermann and von Raumer's results.	Mine.
Number of flower stems ...	100 : 152	100 : 165
Number of capsules ...	100 : 174	100 : 194
Weight of seeds ...	100 : 205	100 : 380

In testing the relative powers of the fed and not fed plants in laying by reserve-material in the winter buds, the Erlangen observers adopted a more accurate method than mine, namely, that of weighing the winter buds, instead of waiting until the new leaves had grown. They found that the weights of winter buds for the fed and not fed plants were as 173 : 100. FRANCIS DARWIN

PHYSICAL SCIENCE FOR ARTISTS¹
V.

THE simple and forcible language employed by Prof. Stokes in the extract I gave in my last paper, should have made it quite clear that in nine cases out of ten, when bodies reflect light to us, they have really absorbed a part of it in the process, and that to this absorption of light bodies by their colours are chiefly to be ascribed.

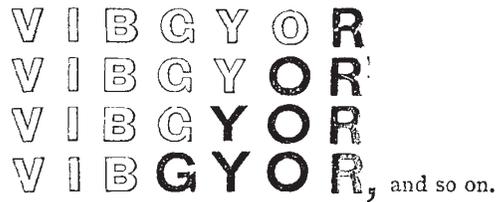
Those bodies which give back to us light in the middle of the spectrum—light, in other words, containing green and yellow—are those which are most liable to change with different intensities of light. I shall endeavour, if I have space, to return to this point in the sequel, but I feel that my first duty, now that the phenomena of absorption have, I trust, been clearly explained, is to pass on to the application of this knowledge to the various colours of the sky.

Having, then, this idea of absorption, a very important consideration comes in: the absorption of a substance generally increases with its thickness, and when we deal with those substances that for a given thickness absorb either the red or the blue, we often find that when the thickness is considerably increased the absorption spreads over the whole spectrum from the blue or the red end respectively. This can be shown graphically as follows:—



¹ Continued from p. 126.

Here, then, we have an absorption beginning at the blue end and gradually closing everything except the red. I may remark *en passant* that we here have the physics of sunrise and sunset colours; similarly we might begin at the red end and then we should get,



These effects may be experimentally observed by either using different thicknesses of the absorbing materials or by putting them into a V-shaped vessel, and observing the change which takes place when the light passes through the greatest and least thicknesses of the absorbing material. It is of importance also for the artist to observe the effect of the residual light independently of the spectral phenomena. For instance: if we take a chlorine tube of such a length that it begins to cut off the

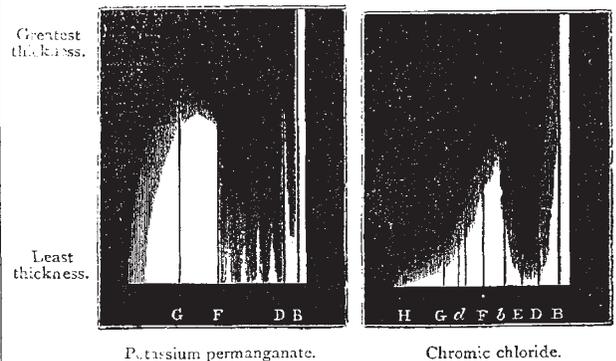


FIG. 1.—Showing phenomena of absorption produced by great and small thicknesses of the same substance in a wedge-shaped cell.

blue the residual light will be a delicate green; a tube twice the length will give us a colour in which the rich golden yellow predominates.

Although we have been compelled to leave out several steps in the argument, we are in a position now to approach the cause of the various colours of the sky.

Let us assume that our complex atmosphere—complex because it consists of a mixture of two pure gases and aqueous vapour—absorbs the light which passes through it, and that the absorptive effect depends upon the thickness of the atmosphere through which the light has to pass before it reaches the eye.

Now there are many grounds for supposing that the

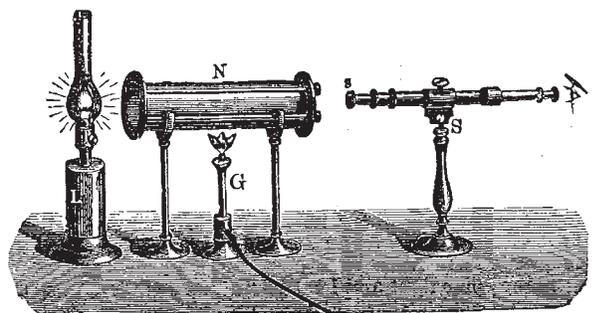


FIG. 2.—Arrangement for observing the absorption of a great thickness of gas or liquid. L, lamp; N, tube; S, spectroscope; G, Bunsen burner when used.

general absorptive effect both of the pure gases and of

the aqueous vapour is of the blue kind: that is to say, that the smallest thickness which has any visible effect will absorb in the blue. We also know that the absorptive effect of aqueous vapour is enormously greater than that of the pure gases.

I feel bound to show at once that this is no scientific abstraction, and it would be impossible to find two better examples to show exactly what I mean than those afforded by two of the pictures which I have chosen as texts—Mr. Vicat Cole's "Rosenlauri" and Mr. Peter Graham's "Wandering Shadows." Whether I am right or wrong about the molecular states of aqueous vapour, there is no doubt that the quantity of it varies considerably. The clouds in Mr. Graham's picture show us that the air is charged with it, for the simple reason that if it were not there would be no clouds to cast the shadows which he has so exquisitely caught. Look now at the dark hill in the distance; see how blue the air is between us and it—for it is true that it is the colour of the air, or rather of the aqueous vapour in the air, as Leonardo da Vinci first discovered, and not the colour of the hill which Mr. Graham here paints. We are in presence of aqueous vapour competent to be set in vibration by blue light, and because it vibrates in this way it appears blue.

What would have happened if the dark hill had not been there? If the stratum of aqueous vapour had had a background of bright sky, it would have absorbed the blue light of that sky. By virtue of the principles which I have stated, the sky would have appeared red in consequence of the abstraction of blue light. This, by the way.

Turn now to Mr. Vicat Cole's picture, and see the work of the vapour upon each receding buttress of rock on the left of the valley; the depth of atmosphere is rendered to perfection, but we do not get the blue that Mr. Graham gave us, for the reason that there is less aqueous vapour mixed up with the air.

Many an artist, I am sure, has noticed that at times there appears to be no atmosphere at all; all sense of distance is lost; buttresses such as those painted by Mr. Vicat Cole, although obviously, as may be gathered from the structure of the mountain, at different distances from the eye, seem yet to lie in the same vertical plane.

I saw this effect myself in its very strongest form last year at Cadenabbia. Looking eastwards from the hotel there, over the lake of Como, one sees Bellagio, the hills between Bellano and Lecco on the other side of what is called the Lecco leg of Como forming a magnificent background; these hills recede from the eye in a magnificent series of buttresses. Although some of these buttresses were three or four miles on the other side of Bellagio, it was impossible to get rid of the feeling that lake, Bellagio, background to the furthest buttress, was a painted canvas between us and the water. I called the attention of several friends to this wonderful sight; they saw it exactly as I did. The explanation is quite simple: although the permanent gases of the air were there, the aqueous vapour was not, at all events, in that form which by its action on light gives us what artists call atmosphere in a picture. To me this afforded the strongest possible proof of the statement I have already made that the absorption of the permanent gases of the air goes for nothing so far as art is concerned.

As I have already hinted, the molecular form of aqueous vapour with which we have most to do is one, the motions of which lie chiefly at the blue end of the spectrum; a small thickness of it cuts off the extreme blue, and as the thickness increases even the green may be dimmed by it.

In order to show how on such a point as this, art, representing an accurate study of natural phenomena, may help science, I will here give the result of some observations which my friend Dr. Schuster was good enough to

make at my suggestion in the Himalayas and Tibet, with a view to test this very question.

Theory had led me to expect that with the enormous thickness of air available there, absorption at the red end of the spectrum by aqueous vapour would be seen as well as the absorption at the blue, which is so common with us. Seeing the sun a vivid green through the steam of the little paddle-boat on Windermere first led me to inquire into the possibility of aqueous vapour following the same law as that which I think we may now accept in the cases of the vapours of metals. As in these experiments with vapours, absorption of the red end alone was seen, as well as absorption at the blue end alone, the assumption that these two absorptions existed in aqueous vapour at once accounted for the green sun, which, I may remark *en passant*, I caught again last year through a thin veil of mist at the extreme summit of the pass of the Simplon.

Here, then, are Dr. Schuster's observations made at Simla when the rainy season had just begun:—

June 27, 8 A.M.—B (one of the Fraunhofer lines at the red end of the spectrum), beautifully shaded. Light visible in the blue as far as 4040; most likely further; but the telescope cannot be moved to greater deviation.

9 A.M.—Space beyond B closes up, while in the blue the spectrum is visible, as before.

11.15 A.M.—The red closed up still more; the blue as clear as before.

6.30 P.M.—Sun very near horizon; spectrum seen from C to G. (This means that both ends of the spectrum are now absorbed.)

Dr. Schuster further states that he was at the same time struck by the fact that the peculiar redness of the clouds in the evening, which we observe so often in our climates, was only rarely seen, and, when seen, that the colour was rather yellow than red. He adds, "On making this remark to a friend competent to judge, and who, through a long sojourn in Simla, was enabled to form an opinion, I heard that the redness of the sky at sunset was often beautifully seen at the end of and after the rainy season."

So much for the observations at Simla. I now pass on to some observations made in Upper Tibet, where there is no rainy season. I give them in Dr. Schuster's own words:—"The observations all point to the remarkable clearness in the blue. As I have said, the hygroscopic state of atmosphere, as measured by the wet and dry bulb or barometric pressure, cannot alone account for all the phenomena. I find, for instance, that the presence of vegetation affects the atmospheric absorption in a remarkable degree. In the Kyan Chu plain, for instance, the plateaus on which I observed the mirage described in NATURE, vol. xiii. p. 67, objects at ten miles distance look as sharp and distinct as those half a mile off; it is, in fact, impossible to judge of distance. Crossing the Tagalung Pass (18,000 feet), we descended from that plain into the Valley of the Indus. As soon as we reached vegetation, at a distance of only two marches from the above-mentioned plain, and at a height still above 12,000 feet, the whole aspect of the country is a different one. Distant mountains now take the lofty blue colour which gives such peculiar charm to the landscape. In the evenings, especially, you cannot help knowing that there is something between your eye and a distant object, which affects its colour and distinctness, and through it you get a standard for judging distances. Without vegetation, even at a lower height, as, for instance, in the Valley of the Bagha (Lahoul), you seem to look through a vacuum. In the upper part of the Valley of the Indus, of which I am now speaking, I have not seen that clearness in the atmosphere which I have invariably seen in Switzerland at a height of 3,000 feet. The strong radiating power of the sun, which stands much more vertical in India, is evidently the cause of this, for it can only be organic matter floating in the atmosphere which can produce such a

striking result; that the absence of any rain or deposit of any kind must not be left out of account is clear. The air in the side valleys of Cashmere, although rich in vegetation, is particularly transparent. Strange enough, the principal valley of Cashmere, *i.e.*, the valley of the Jehlum, is generally hazy, although there is a good deal of rain. I have seen the planet Mars look almost white; Jupiter and the other stars at that time had a bluish tint."

I have been anxious to give these extracts not only because they form a valuable contribution to science, but because we see here the student of science doing what an artist is generally supposed to do, namely, interesting himself in the colouring of natural objects, and I cannot omit pointing this remark with the statement of my belief that when the artist attacks these also from the scientific point of view as well as the artistic one, his eye will lose nothing of its keenness, and his interest in the glory of nature will be nothing the less.

Let us consider, then, the action of those molecules which absorb the blue light.

Now since these molecules absorb blue light we know that they will reflect blue light, and, practically speaking, nothing else. Here, then, we have the cause for the blue colour of the sky.

Those who are familiar with the brilliant researches of Dr. Tyndall on the action of light upon vapours will recollect that he also has arrived at a somewhat similar conclusion from a different line of reasoning and a different method of experimentation.

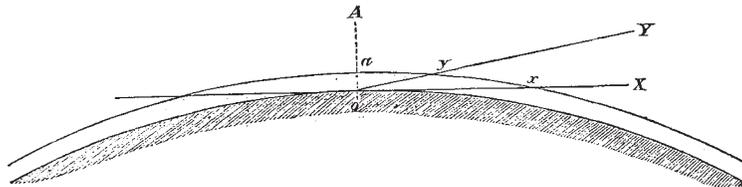


FIG. 3.

somewhere between forty and fifty miles thick. On the assumption that the aqueous vapour, which, as I have shown, is the effective absorber in the air, is equally distributed, let us see how the question of thickness of absorbing layers comes in. Take an observer at o , supposing him in the tropics, and that he sees the sun overhead at A ; notice the distance oa , which represents the thickness of air traversed when the sun is overhead, and compare it with ox , when the sun is rising or setting as at X , and when, therefore, the greatest thickness is traversed, taking no account of refraction.

The whiteness of the sun at a high altitude and the redness of it when rising or setting is associated then with the fact that at these times the light traverses the least and greatest thickness of the atmosphere respectively; an intermediate height of the sun is represented at Y , and obviously the distance oy will vary for intermediate altitudes from oa to ox .

Now the thinner we make our atmosphere the greater will be the difference of the thicknesses oa and ox , and, as a matter of fact, the effective aqueous vapour lies very low down; so that the differences will be greater when we consider the aqueous vapour alone than when we consider the whole atmosphere. The thickness of the aqueous vapour, therefore, increasing from a to x , let us take the case of a perfectly clear sky at sunset; the white light reflected, as I have already shown, in conjunction with the blue, will find itself most absorbed in the line ox , least absorbed in the line oa . In the line ox we get everything absorbed but the red; we get, therefore, a red sky. A little higher everything is absorbed but the red, orange, and yellow; this will produce a rich golden colour above the red; higher still, the green and part of the blue is allowed to pass; in fact,

To return one moment to oxygen and nitrogen, the gaseous constituents in our atmosphere, I must here remark that we have no evidence that the pure gases in our air change their molecular constitution; but we know that the aqueous vapour does to an enormous extent, and there is one state to which at present no reference has been made. There is a condition of aqueous vapour which is competent to absorb white light without giving rise to any coloured phenomena; this is the form of which mist and clouds are built up; why they are so dazzlingly white in the sunshine; why we have a dark grey day absolutely devoid of colour when a pall of cloud hangs over the whole sky. In addition to this we know also not only that condition to which I have already referred, which absorbs in the blue, but certainly of one, and in all probability two which absorb in the red. One of these absorptions indicates that the form of vapour which produces it is of the most delicate kind, while that which gives us the continuous absorption in the red end is perhaps the last stage reached before clouds are formed. If this be so, the very complex nature of the true cause of sky colour will be obvious. We have three molecular colour-giving states to contend with, and the action of these will depend largely upon the thickness of aqueous vapour traversed by the sunlight. A diagram will at once explain how the action of these different thicknesses is brought about.

In the diagram, Fig. 3, we have a section of a part of the earth and its atmosphere, supposing the latter to be

only the extreme blue is absorbed; and, as I stated before, when I referred to the absorption of chlorine gas in a tube, the residual light will be green. Above the green we have the blue.

This is the order of the colours of the sky; the sun in consequence of its greater brilliancy can overcome this absorption until it has reached a very extreme limit, *sunset clouds lighted up by the sun, therefore, must put on the colour of the sun*, because the light which has reached our eye is red light, which has travelled to us *via* the cloud, hence the green is limited to a band of sky, between the gold and the blue, a green cloud is impossible, and it is on this ground that I ventured to criticise Mr. Ellis's picture, "The Last of the Wreck," 555. Mr. Ellis has painted green clouds; I am certain he never saw one in his life; for a similar reason I have objected to Mr. Oakes's picture, "The Dee Sands." Sky colour is begotten by a low sun.

I do not think that after what I have said it is necessary to point out how it comes that the blue clouds which Mr. Thornburn has chosen to paint are also impossible; a cloud can only be of a colour which is got from the sun directly or indirectly. Now a blue sun is possible, but clouds illuminated by a blue sun are impossible in a picture, because for the sun to be blue there must be nothing but a thick veil of mist.

I have drawn another diagram, which, although it looks rather complicated, may, I think, be rendered clear by a short description. The object I have had in view has been to show how the colours of the sky may be complicated after sunset. I believe in three pictures of sunrises or sunsets out of four, the phenomena presented have really been observed after sunset, in fact, in most pictures of sunset, the sun is a little too slow, we get sunset colour too soon.

In Fig. 4, oX representing the direction of sunset or "sunrise," my object is to show that a cloud high up, say at x , when the sun has set so long as to be at S^3 in-

stead of at X can really receive light from the sun, and the distance xs'' added to ox will represent the total amount of atmospheric absorption undergone by the light. It is

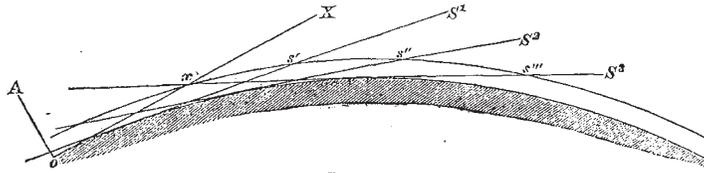


FIG. 4.

under these conditions, too, that, in consequence of the reduced illumination of the background, the sky puts on its most beautiful green, which I think is partly a physiological effect due to the molecular constitution of the retinas of our eyes. Similarly, by drawing a line from S^1

we can see how a cloud absolutely in the zenith of the observer at o may have its colour transformed by a considerable atmospheric absorption *after sunset*.

J. NORMAN LOCKYER

THE MICROPHONE IN SURGERY

ON Tuesday at 3 P.M., before a crowded audience of students and medical men, Sir Henry Thompson gave a demonstration in the anatomical theatre, University College, on the microphone as applicable in operations for stone.

In old days, the lecturer said, patients used to be sent away when they came to the doctor "because their case was not ripe." The risk involved in the operation of cutting for stone was so serious that a surgeon seldom liked to undertake it except under compulsion, and when cutting had to be resorted to it was not much more difficult to remove a large than a small calculus. In the newer operation of stone-crushing it was better, of course, to have the stone to be crushed as small as possible, and it was essential to deal with the smallest fragments to which the operation reduced it. It was often said, indeed, in objection to lithotripsy that to leave even the smallest fragment as a nucleus was to render further treatment necessary and, in time, inevitable. However that might be, it was clearly important to be able to deal with the smallest calculus in the bladder.

Before going further, Sir Henry Thompson emphatically stated that in his belief the present methods of lithotripsy are quite sufficient in the hands of any surgeon of fair practice in the operation to enable him to deal successfully at all events with almost every case. He compared the use of the new instrument which he was going to describe to that of the endoscope for the urethra, which, however satisfactory on paper, had not been found important in practice, or, better perhaps, to that of the higher powers of the microscope, which were not necessary nor perhaps even advantageous in ordinary work, but which were a valuable resource in questions of unusual difficulty.

The apparatus consisted of the ordinary feeble battery with wires, connected with two telephones running to different parts of the room, and applied to the ears of the listeners. The ordinary Sound used in operations for crushing the stone was attached by a wire to the circuit of the battery. Near the handle a piece of carbon, such as is used by Prof. Hughes, was carefully balanced and attached by a delicate spring to the battery circuit. When the end of the sound strikes against the smallest piece of calculus the acoustic wave is transmitted along the steel of the instrument to the carbon, where it is transformed into electric vibrations, which are multiplied through the telephone, so that the noise becomes loud and unmistakable. But Sir Henry Thompson pointed out that in practice many things might interfere with the advantageous use of the instrument. The carbon arrangement on the sound must not be too delicate—not such, for in-

stance, as could make us hear the walk of the fly like the tramp of an elephant—else the mere friction of the instrument on the walls of the bladder would produce a noise quite capable of being confounded with that caused by the presence of calculus. The battery must not be too strong, else mere accidental friction of the wires or the noises of the room would produce a distinct sound in the telephone. But when care was taken there would be no difficulty in detecting the noise. An ordinary calculus was put in a bladder in a basin of water, and the listeners could distinctly hear the different noises produced by the point of the sound rasping against the walls of the bladder or striking the stone. A sharp stroke of the former was sometimes not quite unlike the latter. But with the microphone properly adjusted, and the battery not too strong, it was not easy by trial to detect the presence of even a minute fragment of unremoved calculus in the bladder. The carbon needed only to be fitted to the probe, of course, to detect bullets or fragments of bone. But while it was quite possible for a skilful surgeon to make himself absolutely certain by means of the microphone of what he was previously only morally convinced of, Sir Henry Thompson did not appear to anticipate any very remarkable results, at least in ordinary practice, from the use of the instrument.

NOTES

WE are happy to state that a Commission appointed by the French Chamber of Deputies has reported favourably on the erection of a large observatory at Meudon, on the site of the Château which has been in ruins since the Franco-German war. The credit given is 690,000 francs, which will be paid in two instalments, 345,000 in 1878, and 345,000 in 1879. A large part of that sum, 390,000 francs, is destined for the construction of a large refractor, 250,000 francs are for the buildings, and 50,000 francs for the salary of M. Janssen, his assistants, and petty expenses during two years. The credit will be voted very likely *nemine obstante*.

WE learn, with much satisfaction, that the Swedish Diet has granted the necessary funds to the Meteorological Observatory at Upsala, so well known for the high excellence of its work, and that it will commence its new course as a separate institution, distinct from the Astronomical Observatory, on January 1, 1879.

ON Thursday, May 30, Dr. Gladstone, F.R.S., P.C.S. gave a *soirée* to the Fellows of the Chemical Society at Burlington House. Amongst the numerous objects of interest were the following:—A magnificent collection of immediate principles from the brain exhibited by Dr. Thudichum, who also demon-