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# XXV. Note on the decomposition of carbonic acid by the leaves of plants under the influence of yellow light

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proportional to the time that it takes to burn, because the consumption in a given time depends upon that time.

If, therefore, a thousand cubic feet of gas be charged 8*s.* on both sides of the river, it is clear that the consumers on the south side pay at the rate of 9*s.* 4*d.* per cubic foot, because they consume 7000 cubic feet in the same time that those on the north side consume 6000.

If Glasgow gas, Skaterigg gas and Lesmahagow gas are each charged at 8*s.* per 1000 cubic feet, the price paid by the consumers will be

| | *s.* | *d.* |
|---|---|---|
| 1000 feet of Lesmahagow gas | 8 | 0 |
| ... Skaterigg gas | 9 | 4¼ |
| ... Glasgow gas | 11 | 6½ |
| ... ... south side river | 13 | 5¾ |

XXV. *Note on the Decomposition of Carbonic Acid by the leaves of Plants under the influence of Yellow Light.* By John William Draper, *M.D., Professor of Chemistry in the University of New York.*

IN the year 1836 I discovered that the leaves of plants possess the quality of effecting the decomposition of carbonic acid under the influence of light which had passed through a solution of bichromate of potash, and which was so completely detithonized as to be unable to darken the chloride of silver. Under the same circumstances also, young plants which had been etiolated by germinating and growing in the dark, turned green in a few hours by the fixation of carbon, so as to constitute chlorophyll. Seeds also appeared to germinate without any difficulty, and eventually produced vigorous green plants.

These results were published in 1837 in the Journal of the Franklin Institute of Philadelphia*; I have likewise referred to them in the Phil. Mag. (Feb. 1840).

From time to time Mr. Hunt of Falmouth has called the accuracy of these experiments in question, and having made some investigations under the direction of the British Association, at its expense, he has published reports on the matter. It is the object of these publications to substantiate a doctrine which is derived from Sennebier, that the blue and violet chemical rays are the true cause of the decomposition.

That there might remain no reasonable doubt of the correctness of the views I had given, I repeated the experiment of

* I will take this opportunity to state that the experiments here alluded to, with some others, are now collected together, and are in the press. They will be in the hands of the English reader in a few weeks.

the decomposition in the prismatic spectrum. An account of this was read by Dr. Kane to the British Association at its meeting at Cork, and a memoir on the subject published in the Phil. Mag. (Sept. 1843). The result of these experiments completely proved the power of yellow light in producing the decomposition. The activity of the different rays seems to follow very closely their illuminating power. Experiments were also undertaken in Virginia, at my suggestion, by Dr. Gardner who resided there, with a view of determining directly whether the greening of leaves was produced by the same rays. As a matter of proof these experiments were not however absolutely required, because in assuming, as I have uniformly done, that the decomposition of carbonic acid and the production of chlorophyll are the same phænomenon, I merely follow all botanical writers. These experiments proved that the green colour is produced by yellow light, the other rays following in the order of their illuminating power (Phil. Mag., Jan. 1844). This is the same result as before; I have caused these experiments to be repeated in one of my laboratories in New York, and need scarcely add that they are verified.

It is therefore with no small surprise that I read in Mr. Hunt's recent treatise, entitled "Researches on Light," the following passage in reference to the memoir published in the Phil. Mag. (Sept. 1843), to prove that the yellow rays of light and not the blue and violet chemical rays brought about the decomposition in question. Mr. Hunt says, "Since this announcement, the very gloomy and uncertain state of the weather has almost entirely prevented my testing the correctness, or otherwise, of Dr. Draper's results. During a few faint gleams of sunshine I have repeated the experiments in Draper's own method, and I have found that *bubbles of air* have been liberated in the tubes under the influence of the yellow and red rays, but they have been *carbonic acid*. In the tubes which were placed in the blue and violet rays alone, a perfect decomposition had taken place, and the bubbles which were collected were *pure oxygen gas*."—*Researches*, p. 198.

Having recently, as the readers of this Journal know, expressed myself very plainly as to the character of Mr. Hunt's book, I do not wish to make any allusion here, except in so far as my experiments are called in question. It is true that I cannot understand how an experiment, which in America requires a most brilliant sun, and which involves some delicate manipulation, is to be made in a very "gloomy and uncertain state of the weather," and amid "a few faint gleams of sunshine." It would seem however that in England it can.

Neither do I understand how it is possible that the violet ray or any other ray can cause leaves to evolve *pure oxygen.* It has happened to me in certain investigations in vegetable physiology to make more than 200 analyses of gas from vegetable leaves. They have never emitted pure oxygen, but a mixture of nitrogen and oxygen, and very often as much as fifty per cent. of the former gas. This result is the same as has been obtained over and over again for more than fifty years. M. Saussure, Dr. Daubeny, and all other competent writers are in agreement upon this point.

Neither can I understand how it is possible that an analysis can be made of the gas emitted by the violet ray. With a brilliant sun and proper precautions taken to exclude extraneous light from the tubes, I have never been able with the violet light to cause leaves to evolve *a solitary bubble of any kind of gas whatsoever.*

I am therefore obliged to infer that there must be some error in Mr. Hunt's method of experimenting, or a want of care in his manipulation. His results on the action of light upon plants are undoubtedly altogether erroneous.

The readers of the Philosophical Magazine who have perused my memoirs, will, I hope, have seen abundant reason to understand that no facts are ever there reported without a thorough evidence of their correctness. In the limited space to which a periodical writer is restricted, much collateral evidence must be laid aside, or communications would become inordinately long. So, in my memoir on the decomposition of carbonic acid, I might have added many other facts. Among the rest I might have given analyses of the gas emitted by the yellow ray. I will conclude this paper by furnishing evidence on that point.

Five tubes, each three-eighths of an inch in diameter and six inches long, were inverted in a small trough of water containing carbonic acid, with which the tubes were also filled. Some blades of grass, nearly of the same size and volume, were placed in each tube. This grass had been kept for two days in the dark, in a bottle filled with carbonated water. During this time the film of air which envelopes all new leaves was removed, the grass became perfectly free from all adhering gaseous matter, and when in the carbonated water exhibited a dark green aspect.

I have previously found that leaves thus soaked emit, under the influence of the light, a larger amount of nitrogen than usual; this comes from the incipient decay of some of their nitrogenized constituents. When, under these circumstances, they are placed in the sunshine, this nitrogen comes off along with the gas liberated from the carbonic acid.

In the experiment I am now relating, a tube arranged like one of the foregoing five evolved, *in the open sunshine*, a certain volume of gas which was composed of

| | | |
|---|---|---|
| Oxygen . . . | 41 | 100 |
| Nitrogen . . . | 59 | |
| Carbonic acid . | 00 | |

The five tubes were placed in the spectrum in the following colours, and emitted the quantities of gas represented in the following table:—

| | | |
|---|---|---|
| 1 | Extreme red and red... | 0·0 |
| 2 | Orange and yellow...... | 19·8 |
| 3 | Yellow and green ...... | 27·4 |
| 4 | Blue........................ | 0·5 |
| 5 | Indigo and violet ...... | 0·0 |

The gas in tube 2, which had been in the orange and yellow ray, was then washed with a solution of caustic potash. After this it still measured 19·8, containing therefore no perceptible quantity of carbonic acid. It was next examined for oxygen, and with the following result:—

Constitution of gas emitted by orange and yellow light:

| | | | | |
|---|---|---|---|---|
| Oxygen . . . | 8·00 | or | Oxygen . . . | 40·4 |
| Nitrogen . . . | 11·80 | | Nitrogen . . . | 59·6 |
| Carbonic acid . | 0·00 | | Carbonic acid . | 00·0 |
| | 19·80 | | | 100·0 |

The gas evolved by the yellow and green rays was next analysed. Like the former, it underwent no diminution by washing with caustic potash. After this treatment it therefore measured 27·4, and on being examined for oxygen yielded as follows:—

Constitution of gas emitted by yellow and green light:

| | | | | |
|---|---|---|---|---|
| Oxygen . . . | 12·5 | or | Oxygen . . . | 45·6 |
| Nitrogen . . . | 14·9 | | Nitrogen . . . | 54·4 |
| Carbonic acid . | 00·0 | | Carbonic acid . | 00·0 |
| | 27·4 | | | 100·0 |

In explanation of the large and variable amount of nitrogen occurring in these analyses, it will scarcely be necessary to remind the vegetable physiologist that it arises from the mode of conducting the experiment. In order to be absolutely certain that no atmospheric air infilmed the leaves, they were soaked in water, and then, when brought into the sunlight, the nitrogen which had accumulated on their tissues from incipient decay diffused out with the first portions of oxygen. As, therefore, more and more gas was evolved, the relative amount of the nitrogen diminished. Thus the reason that the third tube appeared to be richer in oxygen than the second, was owing to its containing more gas. Any person, however, who is familiar with the physiological action of leaves will understand these things without any further explanation.

June 15, 1844.

## XXVI. *On a Combination of Lenses for the Photographic Camera Obscura.* By Geo. S. Cundell, *Esq.**

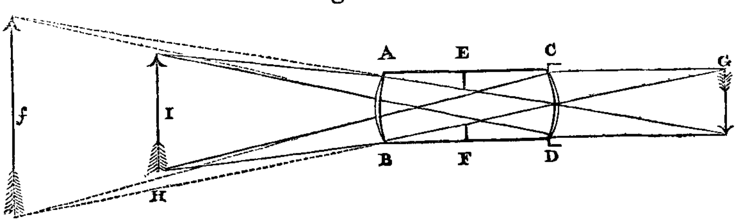
UNTIL within the last few years, the camera obscura has not been an instrument of sufficient importance to command much attention; photography, however, has conferred upon it a new character; and many attempts have recently been made to improve it, with various success.

To adapt the instrument to photography, the principal object is to obtain what is called "a *flat* field," or a picture which shall be in focus throughout, in the margin as well as in the centre; but, along with a flat and focal field, it is necessary to obtain a vivid and well-defined picture, with sufficient *light* to act energetically; and this last condition is especially required when living figures are to form any part of the picture.

It has been shown by Dr. Wollaston (and has been pointed out in a late number of the Philosophical Magazine†), that a lens of the meniscus figure, under certain conditions, will give a picture which, although not absolutely flat, is much more so than can be obtained by any other means; and, had he contemplated the adaptation of the instrument to photography, he would probably have made a small addition to it, similar to that about to be described.

All that his instrument requires, to make it a very perfect one, is a higher intensity of light; and (without impairing its other properties) it will be found, that that may be very efficiently given, by the following arrangement:—

Fig. 1.




* Communicated by the Author.

† May 1844, S. 3, vol. xxiv. p. 321.