
Several years ago, the effect of narcotic and irritant gases on plants was made the subject of a joint series of experiments by Dr Christison and the late Dr Turner, whose evidence was called for in a case then pending before one of our law courts, in which damages were claimed for destruction of trees and deterioration of property, said to be caused by the exhalations from a black-ash manufactory that had been established in the vicinity. The question, then, of the effects of gases on plants is of more than a purely scientific interest, and claims attention even from those who look on every scientific inquiry as valueless unless it have some immediate and obtrusive bearing on human concerns.

The experiments which I now proceed to detail are many of them repetitions of those performed by Drs Christison and Turner, with a view to test their accuracy; with this difference, that the proportions of the gases employed in the experiments of Christison and Turner have been purposely avoided. Some of the gases, however, have been experimented with by myself only; nor are all, or nearly all, of my experiments detailed, but only such as seemed most illustrative.

The modus operandi, when large quantities of the gases were to be employed, was simply to collect the gas in the usual way into stoppered bottles of known cubic capacity, and to allow it to diffuse under bell-jars covering the plants. These bell-jars were rendered perfectly air-tight, by causing their edges to rest on a bed of glazier's putty, pressing the jars down tightly, and securing against any crevice by puttying the outer edge. When the quantities to be used were small, by means of a hole bored in the table we could inject, with a graduated glass syringe, with perfect accuracy, any quantity of the gas, from four cubic inches to the 1/27th of a cubic inch.

* This paper was given in as an essay in the Botanical Class of the University of Edinburgh, and gained the prize offered by the Professor.
Narcotic and Irritant Gases on Plants.

I. Sulphurous Acid.

1. A young Laburnum and Psoralea were introduced into a jar of the cubic capacity of 2000 inches, along with $\frac{4}{3}$ cubic inches of the SO$_2$, or in proportion of 1 to $444\frac{1}{4}$. No change was remarked until the plants had been exposed to this atmosphere for six hours, when the leaves began to shrink. They were then left overnight, and, when examined next morning, or after an exposure of twenty-two hours, the Psoralea was found to be perfectly dead, lying flat on the earth, with its leaves all shrivelled and discoloured. The Laburnum was also so much affected as to be to all appearance likewise dead; the leaves drooped, and were of a yellowish brown colour. The main stem still continued succulent to a certain extent, but the plant had been so powerfully acted on as to be beyond recovery.

2. Into a jar of 2000 inches cubic contents was introduced a young Laburnum, with the fourth of a cubic inch of the gas, or 1 in 8000. In twenty-four hours the cotyledons had become discoloured at their junction with the stem, and in forty-eight hours they were dry, shrivelled, and the leaves drooping. At the end of seventy-two hours no farther change had taken place, except that there was a slight inclination of the petiole to droop. On the fifth day of exposure the drooping had become decided, but as yet no discoloration had shown itself. On the sixth day no further change had taken place, but, on the seventh, the edges of some of the leaves had become of a fawn colour, and the leaflets had folded on themselves.

3. Another Laburnum was placed under a jar of 200 inches cubic capacity, with four-fifths of a cubic inch of SO$_2$, or 1 in 250. In twenty-four hours, no effect of the gas had taken place. In forty-eight hours, a slight tendency to curling of the leaflets had set in; and by the third day the leaves had drooped considerably. On the fourth day the summit leaves exhibited a decidedly withered appearance. By eight o'clock of the seventh day, the cotyledons had dropped off; and by two o'clock P.M. of the same day, the plant, in some of its leaves, became completely discoloured, and hung down as if dying. The plant was then removed, and ultimately recovered, but not without first shedding its leaves.
Mr Livingston's Experiments on the Effects of Hydrochloric Acid.

Though, as we have seen, SO₂, in very small proportions, acts powerfully as an irritant poison on plants exposed to its influence, hydrochloric acid will be found to be even more injurious.

1. A Laburnum was placed under a jar containing 2000 cubic inches of air, with 4½ cubic inches of hydrochloric acid gas, or in proportion of 1 to 444½. In forty minutes, the plant had assumed a greenish gray hue. In twenty-two hours the cotyledons had become quite brown, dry, and shrivelled—the leaflets had likewise become shrivelled, and of a dark olive colour.

2. Into a jar containing 200 cubic inches of air, 24 cubic inches of HCl, or 1 in 8³, were introduced, along with a Balsam. In half an hour the plant had begun to droop, and exhibit discoloration on the margins and tips of the leaflets. In one hour and a half the drooping had become very considerable, and the plant had a flaccid appearance. In twenty-two hours it was quite dead, the leaves had become quite brown, and their tissue had so little tenacity as to go to pulp when handled.

3. Into a jar containing 84 cubic inches of air were introduced four-fifths of a cubic inch of HCl, or 1 in 105, along with a Psoralea. In ten minutes it had shrivelled considerably, and in one hour and a half some of the leaves had become discoloured, and the whole plant had a flaccid appearance. In twenty-two hours very many of the leaves had become half discoloured, and several wholly, while most of the petioles hung down.

4. One-fifth of a cubic inch of this gas was passed into a jar containing 2000 cubic inches of air, or 1 in 10,000, along with a Balsam. In half an hour one of the cotyledons had become discoloured on the edge, and a tendency to droop, though slight, was visible. By the time it had been exposed one hour and a half, the drooping had become most decided, and a tendency to shrivel had exhibited itself. In twenty-four hours the leaves were hanging down, and in forty-eight hours they had become brown at tips and edges, the cotyledons were dry and withered, and even the main stem drooped a little. When taken out, the cotyledons and three of the leaves...
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fell off. The plant was transferred to a hothouse, where it recovered, but parted with all its leaves; young ones were however soon put out. It was not a little curious to observe that many of these were withered at the tips, from the leaf, in its very young state, being subjected to the withering influence of the gas; but the plant still possessing vitality sufficient to develop the entire leaf and leaf-stalk, the traces of the violence done it in the bud continued, and would continue, to present themselves during the life of the plant.

III. Chlorine.

1. A young Laburnum was put into a jar containing 2000 cubic inches of air along with 4\(\frac{3}{4}\) cubic inches of chlorine gas, or 1 in 444\(\frac{1}{2}\). In an hour and twenty minutes a very slight tendency to browning of its leaves took place. In twenty minutes more, the tendency to discoloration had become decided. For the next few hours the gas showed its effects less rapidly, as no great increase of the discoloration took place; but in twenty-four hours the leaves had completely lost colour and were seemingly dried up and drooping. This plant, which was also removed, as in the former cases, shed its leaves, put out new ones, and became as vigorous as ever.

2. Into a jar containing 2000 cubic inches of air another Laburnum was introduced, with 12 cubic inches of chlorine, or 1 in 166\(\frac{2}{3}\). In less than an hour some of the leaves had become completely discoloured—all of them more or less so; but as yet no drooping had taken place. In less than two hours many of the leaves were quite blanched, and only one had entirely resisted the action of the gas. We observed that the blanching invariably began at the tips of the leaves, and gradually crept along to their base. By the time twenty-four hours had elapsed, the plant was completely blanched, with the exception of the terminal leaf-bud, which remained apparently unaffected—both in this and the preceding experiment—probably because the leaf being undeveloped, it had not begun to aid in the respiration of the plant, and so had not imbibed any of the noxious vapour. In both these experiments the stem remained green and succulent, and the plant
ultimately recovered, with only the loss of its first crop of leaves, from a violence that to all appearance seemed likely to prove fatal to it. It soon, however, put out a new and vigorous foliage.

IV. Sulphuretted Hydrogen.

1. Into a jar of the capacity of 2000 cubic inches a young Laburnum and Balsam were introduced, along with 4½ cubic inches of sulphuretted hydrogen, or 1 in 444. In twenty-two hours no change of colour had ensued, but both plants were drooping—the Balsam very considerably, and the Laburnum slightly. In twenty-seven hours the drooping in the Laburnum had increased, but no change of colour had taken place; the Balsam was hanging its leaves quite perpendicularly, but, like the Laburnum, had not been in the least discoloured. The plants were removed, and at first seemed to be likely to recover, but of a sudden they drooped, and died completely down.

2. Two similar plants were introduced into a jar containing 200 cubic inches of air, along with 7 cubic inches of the gas, or 1 in 28. In twenty-four hours the Balsam had drooped only slightly, and the Laburnum scarcely at all. In twenty-seven hours, the Laburnum drooped not only its leaves, but even one of the petioles; but no discoloration was observed. The Balsam drooped much, some of the leaves falling off in removing it from under the bell-jar, but it was not otherwise affected, continuing as green as when introduced. This result is a curious one, as seeming to show that a large volume of the gas affects the plants, to all appearance, less than the smaller quantities.

3. Into a jar containing 130 cubic inches, a Balsam was placed, with four-fifths of a cubic inch of the gas, or 1 in 162. No effect was visible on the plant after exposure to its influence for twenty-four hours, but in twenty-seven hours it drooped. When removed after that time, though the plant survived, it never after seemed healthy. It may be remarked, in all the above experiments with HS, there was along the margin, and on the tips of the leaves, a copious deposition of drops of water.
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V. Ammonia.

1. A Balsam was next introduced into a jar of the cubic capacity of 180 inches, along with 2 cubic inches of ammonia, or 1 in 90. In twenty-six hours the plant had drooped considerably, but not a trace of discoloration of the leaves had taken place.

2. A similar plant, placed in 85 cubic inches of air, along with one-fourth of a cubic inch of ammonia, was not affected in twenty-six hours beyond a very slight drooping. No discoloration was remarked, the plant being as green and succulent as when put in.

VI. Protoxide of Nitrogen (NO) or Nitrous Oxide.

1. Into a jar of cubic capacity 2000, was placed a Balsam, with 24 cubic inches of protoxide of nitrogen, or 1 in 83\(\frac{1}{4}\). In half an hour the plant had drooped considerably. In nineteen hours the drooping had not increased, but one of the leaves had shrivelled, and a cotyledon lay on the ground. Two of the leaves had their tips covered with mould, but they were as green as at first. In forty-three hours no change seemed to have taken place, farther than that now the other cotyledon and a leaf had fallen off. In sixty-eight hours no effect was remarked beyond what had already shown itself, and the plant was removed, but rapidly died down.

2. A Balsam was introduced under a jar containing 200 cubic inches of air along with 26 cubic inches of NO, and in half an hour the plant drooped, though slightly. No increase of the drooping took place in nineteen hours; but two of the leaves were covered with mould, and were lying on the ground. The plant was allowed to remain exposed to the influence of the gas for three whole days, but showed no symptoms of having been further affected. When removed after that time, it died quickly down.

VII. Carbonic Oxide.

1. Into a jar of cubic capacity of 130 inches, a Balsam was placed, with 4\(\frac{1}{2}\) cubic inches of CO, or 1 in 28\(\frac{2}{3}\). In nineteen hours there was evident drooping and a slight shrivelling of
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some of the leaves. One leaf had fallen off, while the bottom of the pot was covered with patches of mould, but no discoloration took place. The effect of the gas did not show any increase in forty-eight hours, except that now two leaves had fallen off. The plant was removed, but died rapidly down.

2. A Balsam was introduced into a jar of cubic capacity of 185 inches, with 7 cubic inches of CO, or 1 in 26\frac{2}{3}. In nineteen hours the plant had drooped much, and a deposit of mould had taken place in the pot. Though allowed to remain for three days, no further effect was produced, beyond the falling off of one of the leaves. The plant died speedily after removal.

VIII. Coal Gas.

1. A Laburnum was introduced into a jar containing 85 cubic inches, along with 4 cubic inches of coal gas, or 1 in 21\frac{1}{3}. In twenty hours its leaves drooped. In twenty-five hours the apex of the main stem had also drooped. The plant, after being left for four days, did not droop further. The cotyledons fell off in the act of removing the plant from under the bell-jar; it however recovered.

2. Into a jar of similar capacity, 50 cubic inches of gas were introduced along with another Laburnum. In twenty-four hours the plant drooped decidedly. It was then removed, and also recovered.

3. A Laburnum and Balsam were placed in a jar containing 180 cubic inches, along with 25 cubic inches of coal gas, or 1 in 7\frac{1}{3}. In twenty hours no perceptible change had taken place. On the fourth day of their exposure to the gas nothing particular was observable. The plants seemed fresh, with the exception of a slight drooping in the stem of the Balsam. Both these plants recovered.

4. Into a jar containing 200 cubic inches, a Laburnum and Balsam were introduced with 4 cubic inches of the gas, or 1 in 50. In twenty hours the cotyledons of the Balsam became slightly curled, while the Laburnum remained unaffected. No further change took place till the fourth day, when the cotyledons of the Balsam were observed to have become much paler and shrivelled, the leaves to have become dry and yellow.
at the tips, and to hang down languidly. In the Laburnum, the apices of the leaves had become paler, and fell off when touched in the most gentle manner. Both these plants recovered. These experiments with coal gas seemed to show that, just as we found with sulphuretted hydrogen, when the proportion is large, the effect on the plants appeared to be less than when the proportions were smaller.

To conclude, then, it will be evident from the preceding experiments that gases divide themselves into two classes as regards their action on plants—viz., into narcotic and irritant gases. This distinction, to whatever cause traceable, is as real in the case of plants as in that of animals. When subjected to the influence of a narcotic gas, the colour, it was observed, never became altered, and the plants looked as green and succulent at the end of the experiment as at the beginning. Whenever the plant began to droop, though removed to a forcing-bed, and watered, in no instance did it recover, but died down even more speedily than it would have done if left to the continued action of the gas. In one word, narcotic gases destroy the life of the plant. With irritant gases, on the other hand, the action is more of a local character. The tips of the leaves first begin to be altered in colour, and the discoloration rapidly spreads over the whole leaf; and, if continued long enough, over the whole plant; but if removed before the stem has been attacked by the gas, the plants always recover—with, however, the loss of their leaves. In a short time they put out a new crop, and seem in no way permanently injured; but, of course, if repeatedly subjected to an atmosphere of irritant gas, the plants were destroyed.

III. On the Poisonous Qualities of Lathyrus sativus in India. By Dr George Buist, Allahabad.

Dr Buist observed that the Lathyrus sativus had caused extensive poisoning among the inhabitants of Allahabad. The use of its seeds as food appeared to give rise to a severe form of paralysis, which in many cases proved fatal.

Mr Giles Munby, from Algiers, stated to the meeting that this plant was used extensively for food by the inhabitants both of the south of Europe and of the north of Africa, and that he had never seen any bad consequences from its use.