at the end of the cell marked B, and under other conditions collect at A. The speed, however, with which these and other movements of the chloroplasts takes place is unusual. Senn[4] has shown that the chloroplasts of Funaria under optimal conditions of light move 4_{μ} in eight minutes. The chloroplasts of the trichomes of Martynia, however, under optimal conditions of light move much faster, in fact, namely, 21_{μ} in seven minutes. In the cells observed it required from 37 to 43 minutes under fairly constant optimal light and temperature conditions for the chloroplasts to traverse the cell. This shifting of the chloroplasts leads to the well known change in chlorophyll color of certain plant organs.

QUANTITATIVE ESTIMATION OF AERATION IN LEAVES.

F. M. Andrews, Indiana University.

It has been known for a long time that air can be made to move back and forth through the stomata of leaves and that this can be accomplished in some plants with only a slight force[1]. Some plants allow the passage of air in this way with marked ease and among them may be mentioned the following: Nymphaea, Funkia, *Calla aethiopica*, *Arum maculatum*, and Rumex[2]. To these I might add *Myriophyllum proserpinacoides* which is cultivated in aquaria.

A quantitative estimation of the amount of air which can be passed through leaves has not been made. The first investigator to see air pass in this way from stomata was Raffeneau Delille[3]. Since that time Sachs[4] and others have worked on the problem.

I have experimented with a number of plants in this respect. One of these was *Nymphaea odorata* which was an especially favorable object. Air was easily caused to pass through the leaf in bubbles with a vacuum of 12 mm. of mercury, which is less force than was required by the specimens of the same genus mentioned by Pfeffer[5]. The same thing was accomplished by arranging the petiole under a cylinder of water filled to a height of about 30 cm. and then inverted over a dish of water as indicated by Jost[6]. The air in this case issued from the petiole with great rapidity and in large quantity. The stream of bubbles can easily be made visible to a large audience by proper arrangement of a lens of correct magnifying power. The volume of air thus passed through the leaf of *Nymphaea odorata* was 10 cc. in 16 seconds. One thing must be borne in mind with *N. odorata* and that is the status of the leaf for

[4] Senn. l. c. p. 320.

[1] Pfeffer, W. Pflanzenphysiologie Zweite Auf. 1891 Bd. 1 pp. 178-179 and literature there quoted.

[2] Pfeffer, W. l. c. p. 179.

[3] Raffeneau, Delille. Annales d. Scien. natur. 1841. XIV 328. Quoted by Von Hohnel Jahr. f. wiss. Bot. 1879. Bd. 12 p. 48. See other literature there quoted.

[4] Sachs, J. Ueber die Bewegung der Gase in den Pflanzen. Handbuch der Experimental-Physiologie des Pflanze 1865 pp. 243-262.

[5] Pfeffer, W. l. c.

[6] Jost, L. Lehrbuch der Botanik. 15 Auf. 1921 p. 216.

an air passage. If the petiole of such a leaf is arranged as above indicated the air may not issue from the cut end of the petiole for a very long time, or not at all under slight vacuum. At times as much as 30 minutes elapse under slight vacuum before the air passage begins. When, however, it has once begun it continues with great rapidity until the expelling force is removed. When the passage of air does not begin at once the suction should be increased by lengthening the mercury or water column till the flow of bubbles commences. The force employed may then be decreased if desired to the minimum amount that will sustain a continuous stream of air bubbles. The stream of air bubbles will cease as soon as the leaf is immersed and will commence again as soon as it is restored to the air. This proves that the failure of air to pass at first under slight vacuum was not caused by the stomata being blocked with water, but was due to other causes. Large quantities of air issued even under the small vacuum. The leaves tested were of medium size, being about 12 cm. wide and 14 cm. long, and were vigorous in every respect.

Myriophyllum proserpinacoides allows air to pass with ease but not quite so easily as *Nymphaea odorata*. For example, a vacuum of 16 mm. of mercury was required to cause the air to flow through this plant from the leaves. The volume of air passed through was much less than for *N. odorata*. For example, it required five minutes for 1 cc. of air to emerge from the stem. The combined amount of surface of many leaves of *M. proserpinacoides* is much smaller than a single one of *N. odorata* so that the difference per unit area is not so great as might be expected.

The genus Rumex offers a very interesting land type of this function in contradistinction to the two foregoing aquatic types. The species experimented with was *R. obtusifolius*. Leaves 10 cm. wide and 16 cm. long were used. In these leaves a vacuum of only 28 mm. of mercury was required to cause the air to flow through the stomata and out of the petiole. Quantitatively the amount of air passed through the leaf was much less than in either of the first two plants discussed. At a minimum vacuum of 28 mm. of mercury only 1 cc. of air passed through the petiole in 17 minutes. As in the case of the first two plants, this flow instantly ceased when the leaf was submerged in water but began again when restored to the air. This, however, did not occur quite as quickly in the case of *R. obtusifolius*. The stomata of the leaves of *R. obtusifolius* are large. If one knows the size of the stomata and the volume of the air which issues, the number of stomata per unit area may therefore be easily calculated. If the leaves of these plants are attached directly through rubber stoppers or in tubes the amount of vacuum necessary to bring about the desired result is so small that the union may easily be made air tight by the use of plastilina. While in most plants the interchange of air is effected with much greater difficulty, the quantitative estimations here given for the three plants above mentioned show clearly the decided capabilities of certain plants in this respect. *Rumex obtusifolius* and *Myriophyllum proserpinacoides* can be used as excellent demonstration material before an audience. When *R. obtusifolius* was connected with a 1200 cc. flask on which a vacuum of 20 cm. of mercury

was placed the air was caused to stream inwardly through the stomata and out of the petiole continuously for two and one-half hours without renewing the vacuum.

AN UNUSUAL IRIS.

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Two years ago I transplanted the rhizomes of some Irises to a rather damp location. All were the common large blue flag (*Iris versicolor*). The rhizomes sent up the aerial parts and produced 60 flowers of which three were unusually large, being 12 cm. long and nearly as broad, whereas the usual length is 5 to 8 cm. This represents an increase in size of at least one third. The inner segments were pure yellow and only about one-half the length and breadth of the sepals. Ordinarily the flowers of this species are colored yellow, green or white toward the center[1]. The petals were marked in places by purple dots which recalled to a degree the appearance of the flower of *Belamcanda chinensis*. The rhizomes from which these three flowers above mentioned came bore in every other instance blue flowers of the normal size and color.

SECOND BLOOMING OF SNOWBALL BUSH IN THE SAME YEAR.

F. M. Andrews, Indiana University.

On September 4, 1922, the writer noticed an account of a snowball bush which was in bloom for the second time that year. The plant was at the home of H. P. Carpenter of Elwood, Indiana, who, upon request, very kindly forwarded to me a cluster of the flowers and a branch with some leaves so that a study of the specimen could be made. He wrote that "the first time it was in bloom the bush was literally covered with blossoms, but the last time there were only a few, probably a dozen or more". This agrees with some other plants which have bloomed more than once in a season and to which the author has previously made reference[1]. The second blooming was conspicuous in specimens that were more or less diseased, due apparently to the attack of fungi or other injury. Injury may easily be caused by the attacks also of insects of various kinds and the snowball is at times injured to a high degree by this means.

The characteristics of the specimens at hand agree with *Viburnum opulus* or what is sometimes called the guelder rose or snowball. The flowers are white and are borne in a long peduncled cyme about 6 cm. in diameter. This however, falls far short of the usual size of the normal cyme clusters of *V. opulus* which often average 12 cm. in diameter.

[1] Gray, Asa. New Manual of Botany Seventh Edition.

[1] Andrews, F. M. Proceedings of the Indiana Academy of Science 1905, pp. 187-188; 1909, pp. 373-374; 1911, pp. 279-281.