having him look at a series of words for about 5 seconds, and then repeat as many as he could in correct order. He succeeded in repeating correctly 5 out of a series of 6 words, and 6 out of 9 words. For a similar series of numbers his memory was much better. He could repeat 7 numerals correctly, and in attempting to repeat a set of 10 made but 2 errors. This is better than the average, but not remarkably so. It should be added that several very striking performances are given by Mr. Kellar in which memory forms a considerable part. It is, however, a very special form of memory, involving the formation of accurate associations and classifications rather than an extended series of impressions.

If we now select those tests in which the records of Mr. Hermann and Mr. Kellar differ markedly from the normal we find as follows: In the quickness of response to a touch and a visual stimulus both the special subjects, and Mr. Kellar as well in response to an auditory stimulus, excel to a considerable extent the average individual. But this quickness of reaction does not appear in the more complicated reactions; and in the most complicated reaction they both fall considerably below the normal. In the quickness of movement we find decided indications of an unusual quickness for both Mr. Hermann and Mr. Kellar. In the scope and accuracy of visual perception we find in part a good record, but on the whole no very decided excellence appears. In tests involving mainly tactual perception and muscular perception, the indication is rather that they are below than above the normal. I might also add that I have repeated a few of these tests upon a local sleight-of-hand performer, and find for him a good record and particularly a great quickness of movement. This is perhaps to be explained by his facility in musical execution as a pianist and organist as well as in sleight-of-hand performance.

The positive results of the investigation are thus small, but as far as they go they are consistent with the forms of dexterity that are utilized in sleight-of-hand performances. They also indicate that it may well be that special skill in one very specialized form of training may be only slightly influential upon other forms of capacity. So little is known of the correlation of powers of this kind, and small series of tests are so apt to be affected by accidental errors, that any suggestions which the data seem to warrant must be put forward with great caution. The individual is interesting, but the methods of research are, and must be, particularly adapted to statistical groups.*

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## *THE INFLUENCE OF CARBON DIOXIDE ON THE PROTOPLASM OF LIVING PLANT CELLS.*

THE history of investigation of the relations of plants to the component gases of atmospheric air and with special reference to $CO_2$ may be said to begin with the researches of Priestley and Ingenhousz (1779). Among the results obtained by the latter was the fact that plants die in 'air' fatal to animals, and that such air contained large portions of $CO_2$. De Saussure next made his famous tests of the effects of the atmospheres containing various proportions of $CO_2$ upon growth (1804), and John found that peas would not germinate in an atmosphere of this gas, and since the seeds were killed by the alcoholic fermentation accom-

* I feel that it is necessary to add that Mr. Hermann perhaps did not do himself justice in some of the tests. He was always quick, confident and decided in his judgments, often performing a test in half the time taken by the average person. He was much interested in the tests, but seemed confident of his ability to do what was required, with little effort. It may well be that with a little more deliberation, and an opporunity of even a brief familiarity with the tests, better results could have been secured.

panying the experiments he concluded that the gas was poisonous to plants (1810). About this time Davy obtained some results confirmatory of those previously attained by De Saussure.

No further important facts were brought out until forty years later when, in the period of activity following the discovery of protoplasm, its relation to carbon dioxide were taken up by Kabsch, in a study of its influence on 'sensitive' plants (Bot. Ztg., 1862). The field attracted many workers of the first rank among whom are Kühne, Boussingault, Pfeffer, Schützenberger, Godlewski, de Vries and Boehm, who paid chief attention to the influence of the gas in varying pressure and proportion upon the synthetic activity of chlorophyll-bearing plants. The discovery of Pasteur that certain forms of Saccharomycetes and Schizomycetes might live in a medium devoid of oxygen, was followed by the experiments of Frankel, in which he found that many forms of these groups might live in an atmosphere of pure $CO_2$, and that the relations of each form to the gas was entirely specific (1889). D'Arsonval, pursuing similar lines of experiments, met no organism capable of continued existence in this gas at high pressures, forty-five atmospheres (1891). Frankland obtained results entirely in harmony with those of Frankel and further found not only great specific differences in resistence to the gas, but also wide differerences in individuals from the same colony (1889). Demoor in some recent work upon the subject in connection with the effects of many different gases reaches the conclusion that the activity of the plasma is possible only in the presence of oxygen, while the nucleus may not be affected by conditions which inhibit the action of the plasma.* Perhaps the most extensive and exact series of experiments dealing with the relations of $CO_2$ to protoplasm devoid of chlorophyll is that recently carried out by Lopriori at Berlin.* This writer used gas obtained by heating potassium bicarbonate, according to the method of Schloesing and Laurent, which was stored in gasometers of special design, and the integrity of all mixtures was confirmed by numerous analyses. The microscopal examination was made in chambers similar in principle to that of Engelmann. Among his more important results are those which concern the accommodation of protoplasm to the unusual proportions of the gas and the germination of spores under such conditions. The streaming movement in the stamen hairs of Tradescantia was inhibited by exposure to a mixture of 20 parts oxygen and 80 parts $CO_2$ for 3 or 4 minutes, and was resumed after a minute's exposure to the air. A second exposure to the same mixture a half hour later had no effect on the movement, and a much greater proportion of $CO_2$ was now necessary to influence the rate of movement. By immersion of the hair in successive mixtures of the following composition:

| | | | | |
|---|---|---|---|---|
| 1. | O 25 parts | $CO_2$ | 75 parts |
| 2. | " 20 " | " | 80 " |
| 3. | " 10 " | " | 90 " |
| 4. | " | " | 100 " |

it was possible to maintain the movement in the pure gas.

The germination of spores of Mucromucedo was totally inhibited in pure $CO_2$ and delayed a varying length of time in mixtures containing high proportions. The myceliæ formed in mixtures containing above 10–30 parts of $CO_2$ did not develop sporangia. In such instances the protoplasm became highly vacuolar, while globular swellings were formed on the myceliæ sim-

*Arch. d. Biol., 13: 163. 1894.

* Ueber die Einwirkung der Kohlensäure auf das Protoplasma der lebenden Pflanzenzelle. Jahrb. f. wiss. Bot. 28: Hft. 4. 531–625. 3 Figs. 2 Pls 1894.

ilar to those resulting from the use of concentrated nutritive solutions. If such structures were brought into atmospheric air vegetative myceliæ were formed. Spores which had been immersed in pure $CO_2$ for three months germinated in the usual manner. In confirmation of Brefeld's work, Lopriore finds that Saccharomyces will not grow in pure $CO_2$, although but one-six thousandth part of oxygen is necessary as has been found by Brefeld. After 12 hours' immersion in the pure gas growth was resumed upon access of atmospheric air. Mixtures containing large proportions of $CO_2$ exerted a much stronger adverse influence upon Mycoderma cerevisiæ, which was killed by twelve hours' exposure to the pure gas.

Pollen grains reacted to mixtures in the most varied manner. Some formed protuberances in the pure gas, and then burst; in others no change was visible, while in others disintegration shortly ensued. Tubes formed in air and exposed to pure $CO_2$ were generally quickly destroyed. Proportions of 1 to 10 parts of $CO_2$ promoted the growth of the tubes, but did not increase the turgidity, which, however, was markedly increased if afterward brought into ordinary air. It will be remembered that in pollen tubes growth-extension of the walls is practically independent of turgidity. In many instances important changes in the plastic and elastic extensibility of the cell wall were induced, in a manner similar to the effects of strong oxygen solutions.

The results of Lopriore's work point to the conclusion that $CO_2$ exercises a retarding influence upon the activity of protoplasm, while directly exposed to it, but has no permanently injurious effect. Different plant cells exhibit widely divergent reactions to the gas. It appears quite well established that animal protoplasm is affected much more strongly by increased proportions of the gas. The influence of the gas upon the protoplasm of plant cells is characteristic, and its effects do not result from the simple exclusion of oxygen; its action is upon the nutritive processes, and since the widest disproportion exists between the volume and the effect produced, if it exercises any stimulating influence the reaction must be so limited as to be easily obscured.

The establishment of the fact that $CO_2$ exercises a positive influence upon protoplasm makes necessary a revision of some of the conclusions reached concerning ærobic and anærobic organisms, and particularly the researches of Correns (*Flora*, 1892) upon the relations of plants to oxygen, in which oxygen was partly or entirely displaced by $CO_2$. The anomalous reactions of tendrils obtained by this author seem to be capable of explanation in view of the recently discovered relations of the gas to plant protoplasm.

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## *NOTES ON CERTAIN UNDESCRIBED CLAY OCCURRENCES IN MISSOURI.*

THE geologically well-known clays of the State of Missouri (which are very abundant and widely known, commercially), occur in the Quaternary—chiefly confined to the loess deposits along the larger rivers; in the Tertiary—in the southeastern part of the State; and in the Coal Measure formations —in the extension of the Iowa Coal Basin southwestwardly, and also in the small outlier of the Illinois Coal Basin, which is confined, practically, to St. Louis city and county.

Another interesting and commercially valuable group of clays, which has, apparently, never been described, includes a large number of more or less isolated pockets of fire clay and 'kaolin,' occurring unconformably in cavities and former valleys among the Silurian and, possibly, in some Devonian and Lower Carboniferous rocks. These pockets of clay are distributed over