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COMPARISON OF ABSORPTION OCCURRING IN CORN STALK TISSUE AND IN PREPARED BIOCOLLOIDS

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Growth, an important function of the plant, is characterized by being possible under a wide range of temperature, moisture, available plant food, and other limiting factors. It is a hydration of the colloidal material (protoplasm) of the plant to which, later in the life of the plant, matter is added. This added matter, of course, increases the dry weight. Protoplasm has been found to adhere so closely in its actions to the laws of artificially constructed biocolloids that many attempts are being made to construct a biocolloid whose behavior agrees with the observed behavior of protoplasm and in that way to determine more definitely its detailed structure and composition. The present study is an attempt to set forth the rate of hydration in corn stalk tissues and in artificially prepared biocolloids.

MacDougal and Spoehr [1] have carried on extensive work along the line of growth as related to increase in size of plant parts. Spoehr [2] has determined the constituents and their arrangement in the cell and MacDougal and Spoehr [3] have investigated the rate of hydration in many biocolloids. MacDougal [4] has compared their absorption with that in joints of *Opuntia*.

MacDougal [5] and Shull [6] show that increases in temperature cause increases in absorption according to definite ratios. MacDougal has found that the maximum swelling of agar and protein takes place at about 40° C., but that the higher the temperature, the greater the early hydration, with a consequent earlier state of complete saturation. He also noted that above 18° C. water is absorbed by *Opuntia* more rapidly than are acid or alkaline solutions.

Material and Methods.— Corn stalk tissue was taken from

1 MacDougal, D. T., and H. A. Spoehr. Growth and Imbibition. Proc. Am. Phil. Soc., vol. 56, p. 289. 1917.
2 Spoehr, H. A. Carbohydrate economy of cacti.
3 MacDougal, D. T., and H. A. Spoehr. The effect of acids and salts on biocolloids. Science N. S., vol. 45, p. 484. 1917.
4 MacDougal, D. T. Imbibitional swelling of plants and colloidal mixtures. Science N. S., vol. 44, pp. 502-505. 1916.
5 MacDougal, D. T. Hydration and growth. Carnegie Inst. Wash. Pub. No. 297. 1920.
6 Shull, Charles A. Temperature and rate of moisture intake in seeds. Bot. Gaz., vol. 69, pp. 361-390. 1920.

vigorously growing volunteer corn which was collected when in flower, October 8th, three days before a killing frost. The fourth to the seventh internodes were selected, split lengthwise, and cut to a length at which they would weigh ten grams. These were dried, and lost about 90 per cent of their weight. The dry tissue was stored in the laboratory until used.

The colloidal mixtures were made up according to the general method for making media. One and five-tenths grams of egg albumen were added to nine hundred cc. of agar after cooling to 40° C. These media were poured on porcelain plates which had been greased with just enough vaseline to show a "grain" when rubbed with the finger. Two hundred cc. were used in each case. After the prepared colloidal material was poured into the plates, it was allowed to remain in the laboratory for some time. Drying was hastened by blowing air over the plates by means of an electric fan. The colloids were later cut into pieces of the desired size, 30 square mm. Further drying was resorted to by placing the preparations in an electric oven held at 70° C. The squares after being trimmed off by means of a sharp pair of scissors were allowed to come to an equilibrium with the air before being used. The average thickness of the dry pieces was 0.145 mm. Throughout the work three solutions were used, namely, distilled water, 1/100 N solution of citric acid and 1/100 N solution of sodium hydroxide. The experiment was carried on at room temperature which was about 24° C.

The colloids were placed in a 7 cm. petri dish without cover which was placed in a 10 cm. petri dish. These were kept in the laboratory locker from which they were taken for weighing. The corn tissue was weighed and put in 100 cc. wide mouthed bottles. Four sections of each colloid and corn tissue were treated with distilled water, sodium hydroxide and citric acid.

The increase in absorption was ascertained by weighing. The weights were taken over a period of 39 days for agar and agar with egg albumen in the acid and sodium hydroxide solutions; 81 days in water was needed to bring the corn stalk tissue to its absorption maximum. The weighings were however, continued until there was a distinct loss in weight or the pieces began to break up so that accuracy could no longer be secured. For the first week the extent of absorption was determined daily but after that weighings were made once a week since excessive handling was not desirable. Before being weighed each piece or section was carefully dried between sheets of filter paper.

Since most of the measurements upon absorption in similarly prepared colloidal mixtures have been upon the basis of an increase in thickness, it was thought that as long as the weighing method was used in the present study, it would be desirable to see how the two forms would correspond.

In Table I, a summary is given of a number of determinations. It will be noticed that there is a comparatively close agreement.

TABLE I. *COMPARISON OF THE PERCENTAGE OF ABSORPTION BASED UPON AN INCREASE IN THICKNESS AND UPON AN INCREASE IN WEIGHT*

TIME IMMERSED	2 DAYS		9 DAYS	
	WEIGHT	THICKNESS	WEIGHT	THICKNESS
Agar water	3022	3011	3463	3338
Agar NaOH	1392	1613	1966	2270

The data given in Table II show the diferences in the total absorption.

TABLE II. *THE TOTAL ABSORPTION IN PERCENT FOR CORN, AGAR, AGAR AND EGG ALBUMEN*

	WATER	SODIUM HYDROXIDE	CITRIC ACID
Corn	863	851	583
Agar	4072	2105	1706
Agar and egg albumen	3921	2002	3457

The accompanying graph, (Fig. 25), shows the comparative rate of absorption. The first weight was taken after four hours and cannot be distinctly shown on the diagram. The early increase in weight cannot be entirely attributed to absorption. This early increase is greater and continues for 20 hours in the constructed colloids while for the corn tissue it is much less. It is a rather striking feature that the maximum point of swelling for each medium is reached at about the same time in the different solutions. For example, the maximum amount of swelling of agar, agar and albumen, and corn tissue in sodium hydroxide is practically reached in 39 days. The curves show many similarities in the rate of absorption, as for example in sodium hydroxide the rather rapid hydration ends in four days. After 19 days there is very little gained. The same general close relation holds true with water. Agar and albumen in citric acid is a notable exception in correlation. This shows a rapid, nearly equal rate of absorption so near as to fall within the range of

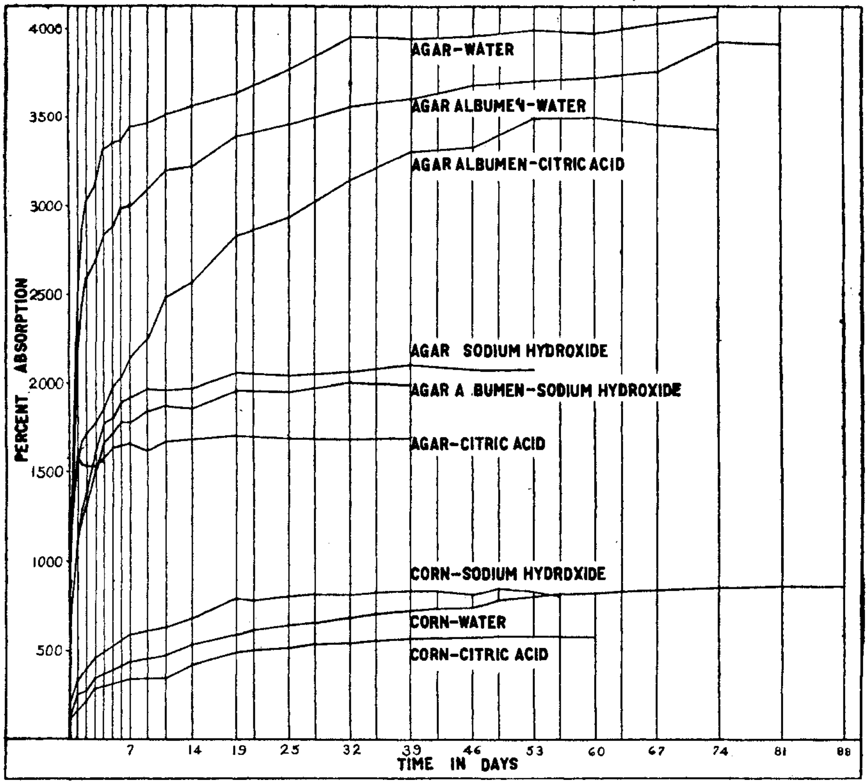

Fig. 25. Graph showing the progress of absorption occurring in corn stalk tissue and in colloidal mixtures.

experimental error. The greatest change in absorption is caused by the addition of albumen to agar, when immersed in citric acid, which for the first day is the same as plain agar in citric acid.

Discussion.— Direct comparison of percentages with other investigators cannot be definitely made because there is such a variation in the conditions under which the work was done. The results as far as their physical nature is concerned, are much the same.

MacDougal has found that in *Opuntia* young tissue absorbs least; mature, most; and old, between the two extremes. We considered this corn tissue to be young and it is likely that mature plants would show a much greater amount of swelling. This might bring the maximum swelling more nearly up to that of agar in acid or alkaline solution. MacDougal has been able to greatly reduce the absorption of water and bring it more nearly equal to that of acid and alkaline solution by the addition of any gum. If this were possible in this case the correlation would be very close. The proportion of swelling in corn tissue and MacDougal's *Opuntia* joints is remarkably similar in that the effects of water and sodium hydroxide are nearly equal and acid solution causes two-thirds as much swelling. It is expected that different plants will vary in their hydration capacities. This would be especially likely if Dachnowski[7] is right in assuming that chemical and enzymatic actions are important factors.

Conclusions.— The comparative rate of absorption of these constructed colloids is quite similar to that of corn tissue, which is, however, much lower.

Plain agar has a very high rate of absorption. This could likely be reduced by the addition of a gum.

Albumen added to agar greatly increases the absorption of acid, and reduces somewhat the absorption of water.

Young corn stalk tissue has a water relation similar to that found for *Opuntia* joints.

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7 Dachnowski, Alfred. Effects of acid and alkaline solutions upon plants. Am. Jour. Bot., vol. 1, pp. 412-440. 1914.