as studied up to the present time it seems doubtful that any great change in the conclusions will be found.

INTERPLANAR SPACINGS

Cellulose Ramie fibers	Hemi-cellulose Phytelephas	Starch grains Potato	Starch grains Corn
6.10 A.U.	5.65 A.U.	6.13 A.U.	5.96 A.U.
5.40	4.99	5.23	5.23
5.15	4.48	4.57	4.99
4.35	3.84	4.05	4.40
3.98	3.56	3.73	3.90
3.40	3.33	......	......
3.20	......	......	......

The significance of the figures given in the table becomes more evident when we recall the chemical composition of the substances and the way in which diffraction lines are produced. For details of the latter we must refer to the literature already cited. In general, however, we may think of the lines as being produced by "reflection" from planes or layers of atoms, and as the result of reflection from hundreds or thousands of those planes very uniformly spaced. The substances are all carbohydrates of the hexose type. The atoms which produce the reflection, therefore, are those of carbon and oxygen. Hydrogen has a negligible reflecting power, and the amount of other elements which might occur is too small to produce diffraction lines.

In the table it will be noticed that the dimensions of the spacings are comparatively uniform for the different substances. The greatest interplanar spacing is about the same in each; that is, in the neighborhood of 6 A.U. All of them are greater than 3 A. U. Since the diameters of oxygen and carbon atoms are about 1.5 A.U. or less, it seems fairly certain that the units which make up the lattice structure of these materials are composed of *groups of atoms.*

It is not, of course, a safe procedure to predict the size of these structural unit groups until the lattice is carefully worked out, but attention should be directed to what seems to be at least a peculiar coincidence. The volume of a $C_6H_{10}O_5$ group of atoms as it occurs, presumably, in the materials[4] is about equal to the volume of an elementary cell whose dimensions are $6 \times 5.5 \times 5$ A.U. Approximately the same values are present in each column of the table. The C_6 group seems to be the structural unit in starch grains[5] and in plant fibers,[6] and from the data so far presented it would not be surprising if that group kept its identity throughout all these materials.

We may feel fairly certain of this much—that in the plant parts with which we have been working units of structure which approach in size that of a C_6 carbohydrate group occur in a very uniform arrangement; that is, they are not laid down in a haphazard manner. On the contrary, each unit is fitted more or less neatly in place so that a definite lattice structure is formed.

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[4] *Ibid.*

[5] *Ibid.*

[6] The data on plant fibers will soon be submitted for publication.

SUCTION FORCE OF SOILS: A NOTE ON THE APPLICATION OF THIS PRINCIPLE IN THE STUDY OF THE SOIL-PLANT SYSTEM[1]

IT was pointed out[2] how the principle of the suction force of a soil may be utilized for the estimation of the soil colloids. The suction force is measured with the aid of a mercury manometer attached to a porous clay candle which is filled with water and inserted in the soil. The capillary and molecular forces exert a pull on the water producing a negative pressure in the clay candle which is registered on the manometer. The greater the amount of colloids in the soil the greater the suction force. The ratio from the same soil multiplied by 100 gives the percentage of colloids in the soil. The figures in the following table will suffice to illustrate the relationship between the amount of colloids present and the suction force. The various types of the same soil series contain various amounts of clay and apparently the suction force follows the clay content.

Clay	Suction force: rise of mercury column on manometer
Percentage	cm.
4.15	16.9
4.68	16.0
7.11	17.9
19.09	29.05
21.82	39.1

The figures on the clay content are taken from the

[1] Paper No. 248 of the Journal Series, New Jersey Agricultural Experiment Stations, Department of Soil Chemistry and Bacteriology.

[2] Joffe, J. S., and McLean, H. C., 1925, "Colloidal behavior of soils and soil fertility. I. Suction force of soils as an index of the colloid content of soils." To appear soon in *Soil Sci.*, v. 20, 1925.

data on the mechanical analyses of the soils as given by the Soil Survey. It will be noted that the soil with a high clay content will pull up a mercury column close to 40 cm which, in terms of a water column, is equal close to 18 feet. The significance of this will be brought out more clearly when we shall presently speak of certain irrigation projects based on the suction force.

Several other applications of the suction force principle may be suggested.

It is known that the roots of the plant imbibe water from the soil with a certain force. Briggs and McCall[3] have produced an artificial root with which they attempted to measure this force. What they actually did was to measure in part the suction force of the soil. Now it is reasonable to assume that since the suction force, as described by the authors, is a property of the surface energy of the substances in immediate contact with the outside wall of the porous candle, then the force exhibited by the soil is the force which plant roots have to overcome when the soil ceases to be saturated. At saturation no force has to be exhibited by the plant roots save that of absorbing the water against gravity. As we decrease the moisture content of the soil the greater the force the plant roots have to exert in order to pull the water. The suction force of the soil as shown by Kornev[4] reaches its critical moment when it is equal to about one half of its saturation. It then drops. This phenomenon may easily be linked together with the wilting point of plants in plant physiological researches. It will be possible to determine the wilting point in terms of the suction force. In clay soils with a relatively high moisture content, wilting appears earlier than in sandy soils with less moisture. The clay exhibits a tremendous suction force which the plant has to overcome, while in sand there is practically no suction force to oppose the pulling power of the plant. The suction force principle may therefore be applied in quantitative studies of wilting coefficients in the soil-plant system. Various soils will differ in their suction force and it is this force which undoubtedly determines the critical point of moisture content in relation to wilting. But there is another aspect of this relation. Caldwell[5] states, and this is borne out by Shive and Livingston,[6] that "under any given set of conditions, the observed soil moisture content at permanent wilting is approximately a constant for each of the soils used, and its value increases with the increase in rate of transpiration, being greater under conditions of high evaporation intensity and declining with decrease in the evaporating power of the air." In the light of the phenomenon of the suction force of soils, the above may be looked upon as follows: when the suction force of the soil is greater than the pulling power of the plant wilting must ensue. The factor or factors which influence the pulling power of the plant, such as high or low evaporation intensity, will shift the equilibrium between the suction force of the soil and the pulling power of the plant. The problem of the wilting of plants may thus be reduced to a study of the two factors: the suction force of the soil and the evaporation intensity of the air as it is linked with transpiration. The advantage of using the suction force expression lies in the fact that it is an inherent property of the physico-chemical make-up of the soil.

Another possible application of the suction force of the soil is a study of the moisture movement in the soil profiles. As mentioned above the suction force of a soil is chiefly governed by the surface effects of the colloid fraction of the soil. It is natural that the movement of the water between the adjacent layers of soil should be controlled by this suction force. A study of the suction force of the various layers of the plowed or tillable soil horizon may reveal some interesting data in respect of the vantage points in the soil in respect to moisture relationships.

When, for the sake of argument, the upper layer of the soil has a suction force of 25 cm and the zero point (no suction force) is at 30 per cent. moisture content, the next adjacent layer has a suction force of 30 cm and its zero point is at 35 per cent. moisture, we may expect a resultant forcing the water downward. There may be conditions whereby the movement of water will be upward. All that will have its influence on the power of plants to imbibe water, and the entire picture of the suction force of the various horizons will give us information on the movement of soil water.

One of the primary objects of the study of the suction force by Kornev[7] was for the purpose of

[3] Briggs, L. J., and McCall, A. G., 1904, "An artificial root for inducing capillary movement of soil moisture." In SCIENCE, N. S. 20, No. 13, pp. 566–569.

[4] Kornev, V. G., 1924, "The suction force of soils." In *Zhurnal Opitnoi. Agron.* (*Russian Jour. of Exp. Agron.*) 22 (Orig. papers) pp. 105–111, (1921–1923).

[5] Caldwell, Joseph Stewart, 1913, "The relation of environmental conditions to the phenomenon of permanent wilting in plants." In *Phys. Resear.* v. 1, no. 1, pp. 1–56.

[6] Shive, John W., and Livingston, Burton E., 1914, "The relation of atmospheric evaporating power to soil moisture content at permanent wilting in plants." In *Plant World*, v. 17, no. 4, pp. 81–121.

[7] Kornev, V. G., 1924, "The absorbing power of soils and the principle of automatic self-irrigation of soils." In *Soil Sci.*, v. 17, pp. 428–429.

irrigation. Only meager data are available on the subject. We may imagine that an irrigation system based on the suction force of the soil could be constructed in the following way: porous clay pipes may be placed in the soil at a certain depth and at a certain distance apart, depending on the suction force of the layer in which the pipes are placed. The source of the water supply may be at a level lower than the field desired to irrigate, since the suction force as shown above will lift a column of water 10 to 15 feet or more, depending on the amount of colloids present. A reservoir may be constructed which when kept at a certain level will supply the water to the soil up to any desired moisture content. In the event of a rain the level of the reservoir may be lowered and the system will serve as a drainage system.

Another use made of the principle of the suction force by the authors is the utilization of the high suction force of one soil to obtain the soil solution from a soil with a lower suction force. This has been done in the following way: two Pasteur clay candles were immersed in two different soils, respectively. The sandy soil with a low suction force was moistened previously and its candle was empty; on the other hand the candle in the dry clay soil with a high suction force was filled with water. Both candles were connected in a closed system with rubber stoppers and glass tubing. The suction force of the clay soil produced a vacuum in its candle taking out the water; this naturally evacuated the candle in the sandy soil and the soil moisture entered the candle. Thus the soil solution was obtained. In brief it meant that the suction force of the soil has been utilized in place of a vacuum pump.

J. S. JOFFE
H. C. McLEAN

NEW JERSEY AGRICULTURAL
EXPERIMENT STATION

AMERICAN MATHEMATICAL SOCIETY

THE two hundred and forty-fourth regular meeting of the American Mathematical Society was held at Columbia University, on Saturday, October 31, 1925, extending through the usual morning and afternoon sessions. The attendance included fifty members of the society.

At the meeting of the council, nine persons were elected to membership in the society, and twenty-five applications for membership were received.

The following papers were read at this meeting:

Definitions and postulates for relativity: H. P. MANNING.

Space-time and mass: G. Y. RAINICH.

Interpretations of Poisson's integral: O. D. KELLOGG.

The summation of a family of series of a certain type: I. J. SCHWATT.

Large primes have at least five consecutive quadratic residues: A. A. BENNETT.

A note on the functional equation $f(x+y)=f(x)+f(y)$*:* MARK KORMES.

Some theorems on continuous curves containing no simple closed curve: H. M. GEHMAN.

On irredundant sets of postulates: H. M. GEHMAN.

A property which characterizes continuous curves: R. L. WILDER.

A theorem on connected point sets which are connected im kleinen: R. L. WILDER.

Note on the continuity of a function defined by a definite Lebesgue integral: H. J. ETTLINGER.

On the expansion of an analytic function in a series of polynomials: J. L. WALSH.

On the position of the roots of entire functions of genus zero and unity: J. L. WALSH.

On isolated singular points of harmonic functions: G. E. RAYNOR.

On the structure of a limited continuum, irreducible between two points: W. A. WILSON.

The algebraic structure of the formulas in plane trigonometry. Third paper: T. H. GRONWALL.

Summation of series and conformal mapping: T. H. GRONWALL.

A new form of the remainder in the binomial series, with applications: T. H. GRONWALL.

Almost-periodic functions of two variables: PHILIP FRANKLIN.

The elementary character of certain integrals related to figures bounded by spheres and planes: PHILIP FRANKLIN.

Concerning the arcs and domains of a continuous curve: W. L. AYRES.

A new method in periodogram analysis: NORBERT WIENER.

The convergence of Bessel's series: M. H. STONE.

The Borel summability of Fourier series: M. H. STONE.

The identities of affinely connected manifolds: T. Y. THOMAS.

The research manuscripts and library of Dr. Robert Adrain, professor of mathematics at Rutgers, Columbia, and Pennsylvania. Preliminary report: M. J. BABB.

Note on the convergence of Fourier series: DUNHAM JACKSON.

New division algebras: L. E. DICKSON.

A theorem on continuous curves in space of n dimensions: H. M. GEHMAN.

The society will hold its annual meeting at Hunter College, New York City, January 1 and 2, 1926. It will also hold a meeting in affiliation with the American Association for the Advancement of Science at Kansas City, December 29 and 30, 1925; on this occasion Professor James Pierpont will deliver the third Josiah Willard Gibbs Lecture.

R. G. D. RICHARDSON,
Secretary