suction of the gas in question through the portion of the eggshell (B-2). The passing gas is measured in an especially designed micro-gas meter (C) and a constant predetermined vacuum is maintained by an adjustable self-controlled monometer (E), operated automatically by electricity.

The volume of gas which passes through the portion of eggshell is read in cc./min./sq. cm. The data are obtained from the table of calculated and corrected values obtained after measurement of the curvature of eggshell by a special micrometric spherometer (Fig. 2).

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A METHOD FOR THE PREPARATION OF FOSSILS

IT is a common practise of paleontologists, when preparing fossil shells, to cement the specimen to be cleaned in plaster of Paris, thereby insuring rigidity and stability against the strain of cleaning. This method is particularly useful in cleaning delicate shells otherwise too fragile to allow complete freeing from their matrix. There is a distinct disadvantage, however, in the use of plaster of Paris because it forms a permanent base concealing one surface of the fossil shell from view.

While preparing Paleozoic star-fishes, echinoids and brachiopods for study, the writer found paraffine to be much more desirable than plaster of Paris as a support for the fossil during cleaning. The advantage of paraffine over plaster of Paris is its easy removability from the cleaned specimen, so that a free valve or star-fish, etc., is obtained as a result of the cleaning. After the matrix has been cleaned from one surface of the fossil, the specimen is cemented in wax poured into a box or other container, with the cleaned surface down in the wax. The matrix is then worked off the opposite surface, leaving a completely cleaned specimen embedded in the wax. For greater rigidity, the specimen and its paraffine base can be cemented in plaster. After cleaning, the plaster is broken away from the wax base and the paraffine dissolved away by xylol or cotton soaked in xylol for very delicate shells. In this way a number of Paleozoic star-fishes of all sizes have been freed completely from their matrix, and many rare and new brachiopod shells have been cleaned internally and externally.

The method has proved useful in preparing such delicate structures as the loops of the Terebratulidae. The loop is exposed on one side, then wax is poured on this exposed surface of the loop. This gives a rigid base which will allow working the matrix away from the loop from the other side. Dissolving the paraffine leaves a free loop.

In order to prevent the paraffine from softening during the cleaning, which is commonly carried out near a strong, hot light under a binocular microscope, it is frequently necessary to plunge the embedded specimen into cold water. As long as the wax is kept cool and stiff it is quite as safe a bedding medium as plaster of Paris. It is sometimes desirable to perform the entire cleaning process under water. Besides keeping the wax stiff, this has the advantage of making a strong contrast between shell and matrix.

By the above method it is possible to secure the interior of either valve of brachiopods in which both valves are in conjunction. The particular valve desired is cemented in the paraffine base. Then the valve whose interior is not wanted is ground away and cleaning of the desired valve progresses.

In making preparations such as those described above, the dental engine is very useful, but for the most delicate work against the shell, needles sharpened to a chisel edge are the best tools.

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SPECIAL ARTICLES

THE UTILIZATION OF ADSORBED IONS BY PLANTS[1]

RESTRICTED Brownian movement of ions is one of the great differences between a nutrient solution and a natural soil. In culture solutions the nutrient ions are free to move (diffusible), while in soils they are "adsorbed" on colloidal particles, fixed in crystals and thus exist under conditions of constraint.

In the study of the liberation of adsorbed ions by the plant itself it is necessary that at the outset the nutrient ions be present in adsorbed form only. Otherwise the free ions in the liquid phase could replace the adsorbed elements (ionic exchange)[2] and the problem would approach a mere nutrient solution experiment. Soybean plants were grown in systems containing but *one nutrient ion* (calcium), which for purposes of comparison was either free in solution or adsorbed on colloids or fixed in the interior of crystals.

EXPERIMENTAL METHOD

(a) *Free calcium ions in the soil solution.* Ca-acetate and $CaCl_2$ are very soluble. $CaCO_3$ furnishes Ca ions according to the CO_2 content of the system.

(b) *Adsorbed Ca ions on colloids.* Prolonged electrodialyses of soil colloids removes all free and adsorbed

[1] Missouri Agricultural Experiment Station, Journal Series No. 329.

[2] H. Jenny, *Jour. Phys. Chem.*, 36: 2217–2258, 1932.

ions and the resulting H-systems can be transformed into pure Ca-colloids by addition of $Ca(OH)_2$. These adsorbed Ca ions are all exchangeable. Putnam clay and colloidal bentonite were thus treated. Artificial zeolite (permutite) was prepared as described previously.[3]

(c) *Non-exchangeable Ca ions in the interior of close packed crystal lattices.* Anorthite, a Ca-alumino silicate, was ground in a mortar and—as all the other dried colloids—passed through a 100 mesh sieve. Only those Ca ions seated in the outer surface of the mineral particles are exchangeable.

Soybean seedlings were put into nursery bottles (four plants) containing a uniform mixture of 300 grams of purified quartz sand and various amounts of the above Ca-compounds. All systems had an initial pH of 7. The water content was adjusted twice daily to 20 per cent. of the weight,

Comparison Between Adsorbed Ions and Non-exchangeable Ions

Fig. 1 (solid lines) shows that the soybean plant can live and do well in media which contain mainly

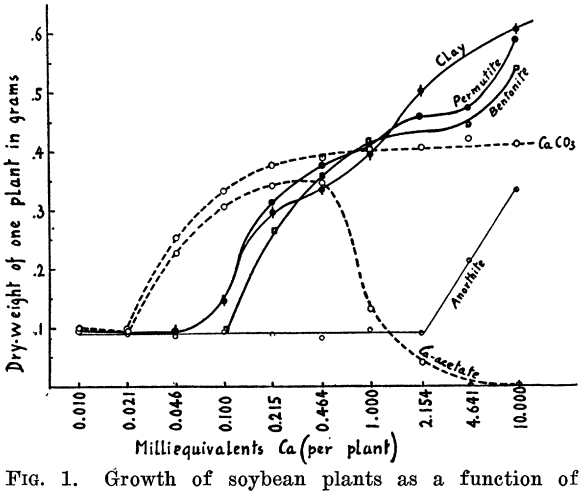

FIG. 1. Growth of soybean plants as a function of amount and form of calcium in the medium.

adsorbed Ca ions. This holds true even for sterile systems, in absence of microorganisms. On the other hand, Ca ions in the interior of crystal lattices can not be utilized or only with difficulty. The growth observed on anorthite at very high calcium concentrations is very likely due to exchangeable surface cations resulting from the grinding process of the mineral.

Comparison between Adsorbed Ions and Free Ions

Under low calcium concentrations the plant yields are much higher for the "free Ca" system than for the "adsorbed" one, indicating that the plant encounters considerable difficulty in obtaining the adsorbed ions. The situation becomes entirely reversed at higher Ca concentrations where, most strikingly, the plants grow best on adsorbed ions, surpassing even the $CaCO_3$ system. This indicates a specific behavior of adsorbed ions in regard to plant growth.

The Mechanism of Liberation of Adsorbed Ions by Plants

Fig. 1 demonstrates that plants are able to free adsorbed ions. This is by no means a simple process. The Ca-colloids used form no true solutions, and the concept of the solubility product can not be applied. In a strictly physico-chemical sense, the Ca-colloids are practically insoluble.

One might conceive the picture that the plant simply removes the adsorbed Ca, attracts it, pulls it away, so to speak. But in this case free electric charges would be left on the particle, leading to enormous potential differences in the electric double layer. It would be difficult to reconcile such a mechanism with the known laws of electrostatics.

It is possible, however, to have a liberation of adsorbed Ca by means of ionic exchange. In such a case—where hydrolysis is negligible—the plant would have to excrete cations other than Ca and these ions would replace the adsorbed calcium. The excreted cations should be found on the colloid. The following experiment is interesting in this respect.

Thirty soybean seedlings were transplanted into 100 cc of 2.50 per cent. pure Ca-clay suspension having a pH of 6.30 and containing 1.500 milliequivalents of adsorbed Ca ions. The plants were harvested 35 days later and after subtracting the original Ca content of the sprouted beans (0.0280 minus 0.0076g. Ca) it appeared *that the plants had removed from the clay 1.020 milliequivalents Ca.* The reaction of the sol had dropped from pH 6.30 to 4.32. Evidently the colloidal particles contained now numerous H ions. These were determined by titration with $Ca(OH)_2$ and it was found that *the clay carried 0.948 milliequivalents H ions which it did not possess at the beginning of the experiment.* In other words, it appears that an exchange has taken place which is stoichiometrical (93 per cent.) within the limits of the present technique. These data and other unpublished trials suggest that *the plant has excreted H ions which have replaced the Ca ions on the clay enabling them to enter the plant.* For every Ca ion that went into the plant, two hydrogen ions are found on the colloidal particles.

Practical Conclusions

(1) It has been demonstrated quantitatively that total analysis of the soil is a poor indicator of soil fertility because the determination does not differentiate between adsorbed and non-exchangeable lattice ions.

[3] H. Jenny, *Kolloid. chem. Beih.* 23: 428–472, 1927.

(2) Since the plant can feed successfully on adsorbed ions, it appears that the significance of the "soil solution" has been overestimated.

(3) The solubility concept is not adequate enough to account for plant growth in soils of humid regions. Ionic exchange must be taken into consideration.

(4) The study of the adsorbed (exchangeable) ions in the soil offers great possibilities for a better understanding of many soil-plant relationships and soil fertility problems (*e.g.*, utilization of fertilizers, distribution of pasture vegetation, soil acidity, activity of soil microorganisms).

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OBSERVATIONS ON EARLY DEVELOPMENTAL PROCESSES IN THE LIVING EGG OF DROSOPHILA

DUE to the fact that the egg of Drosophila is covered by a semi-opaque chorionic membrane, our knowledge of the course and rate of early developmental processes has, up to the present time, been gained only by a study of preserved material, prepared by means of the usual cytological technique. Such a study has not only been a laborious one because of the inherent limitations of a method requiring the reconstruction of a three-dimensional object from serial sections, but it has also been open to error because of the uncertainty as to the age of an egg at the time of deposition. This latter source of difficulty has heretofore been overcome to a large extent by keeping under observation a laying female, rejecting the first eggs laid, and carefully timing eggs laid subsequently. Under suitable conditions, fertilized eggs are not retained by the female for more than twenty minutes.

During the past summer, we found a simple and satisfactory method for observing early embryonic development in the living egg. An egg, firmly imbedded in the agar in which it has been laid, or fastened to a glass slide by a film of Ambroid cement, may be dechorionated with fine, sharp needles under a binocular microscope. It is then mounted in water, and a thin coverslip, supported by bits of glass, placed over it. As the inner membranes are transparent, developmental changes may be followed under high powers, though the definition of the earliest cleavage figures is somewhat obscured by the overlying yolk granules. While under observation, the egg can be rolled about by pushing the coverlip slightly from side to side.

In the early egg, the protoplasmic islands around the first cleavage nuclei appear as lighter spherical regions well marked off from the dense surrounding yolk. As cleavage proceeds, these islands increase in number and decrease in size, giving the egg a "dappled" appearance. Soon a lighter grayish cap arises at the posterior end, presaging the formation of the pole or germ-tract cells. These are pushed out as large buds, which then constrict off from the underlying ooplasm with great rapidity, forming a conspicuous layer; this is separated from the adjacent ooplasm by a clear fluid-filled space. At a temperature of 22° the pole cell formation is approximately complete within 20 to 30 minutes after the first bud forms. Protoplasmic islands containing the yolk nuclei now remain in the center, while the cleavage nuclei migrate to the periphery of the egg to form the blastoderm. Here they push out bud-like prominences over the entire surface, except in the region of the pole cells. This gives the cleaving egg a morula-like appearance, which is most pronounced at the anterior end. Dividing walls can now be seen growing inward and enclosing each blastodermic nucleus in a cubical protoplasmic area which is still continuous with the central yolk mass. As cleavage proceeds, these cells increase in number, are compressed against each other so that they are now distinctly columnar, and finally develop inner walls cutting them off from the central protoplasm. At the posterior end of the egg the blastodermic layer next forms a continuous wall beneath the pole cells.

At a temperature of 22° the pole cells retain their terminal position for approximately an hour, when suddenly they begin to migrate with great rapidity toward the dorsal surface. This migration initiates a series of changes: the first of which is a dorsal invagination in the mid line. Into this invagination, which arises about one fifth of the distance toward the anterior end, the pole cells are pushed.[1] At the moment when the pole cells begin to descend into the cup-like invagination, the cells along the entire dorsal surface begin to group themselves into metameres. These are pronounced by the time the pole cells disappear within the dorsal invagination. At 22° C. the entire series of growth changes, including migration, invagination and metamere formation, occurs within the brief period of 10 to 15 minutes.

Cinematographic records of the processes described above as well as of subsequent embryological changes are now being made, and will serve as the basis for a more extensive report to be given later.

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[1] The force exerted seems to be due to a rapid upward growth of the ventral blastoderm. This point, however, needs further careful study.