

uity assumption. But nearly the whole of Euclid can be obtained without any continuity assumption whatever, and this great part it is which forms the real domain of elementary geometry.

Continuity belongs, with limits and infinitesimals, in the Calculus.

Professor W. G. Alexejew, of Dorpat, in 'Die Mathematik als Grundlage der Kritik wissenschaftlich-philosophischer Weltanschauung' (1903), shows how men of science have stultified themselves by ignorantly presupposing continuity. He calls that a higher standpoint which takes account of the individuality of the elements, and gives as examples of this discrete or discontinuous mathematics the beautiful enumerative geometry, the invariants of Sylvester and Cayley, and in chemistry the atomic-structure theory of Kekulé and the periodic system of the chemical elements by Mendeleejev, to which two theories, both exclusively discrete in character, we may safely attribute almost entirely the present standpoint of the science.

Still more must discontinuity play the chief rôle in biology and sociology, dealing as they do with differing individuals, cells and persons. How desirable, then, that the new freedom should appear even as early as in elementary geometry.

After mathematicians all knew that number is in origin and basis entirely independent of measurement or measurable magnitude; after in fact the dominant trend of all pure mathematics was its arithmetization, weeding out as irrelevant any fundamental use of measurement or measurable quantity, there originated in Chicago from the urbane Professor Dewey (whom, in parenthesis, I must thank for his amiable courtesy throughout the article in the *Educational Review* which he devoted to my paper on the 'Teaching of Geometry'), the shocking tumble or reversal that

the origin, basis and essence of number is measurement.

Many unfortunate teachers and professors of pedagogy ran after the new darkness, and even books were issued trying to teach how to use these dark lines in the spectrum for illuminating purposes.

There is a ludicrous element in the parody of all this just now in the domain of geometry.

After mathematicians all know of the wondrous fruit and outcome of the non-Euclidean geometry in removing all the difficulties of pure elementary geometry, there comes another philosopher, a Mr. Perry, who never having by any chance heard of all this, advises the cure of these troubles by the abolition of rational geometry.

Just as there was a Dewey movement so is there a Perry movement, and books on geometry written by persons who never read 'Alice in Wonderland' or its companion volume, 'Euclid and his Modern Rivals.'

But the spirits of Bolyai and Lobachevski smile on this well-meaning strenuousness, and whisper, 'It is something to know what proof is and what it is not; and where can this be better learned than in a science which has never had to take one footstep backward?'

GEORGE BRUCE HALSTED.

KENYON COLLEGE.

THE SOCIETY FOR PLANT MORPHOLOGY
AND PHYSIOLOGY.

THE seventh regular annual meeting of this society was held, in conjunction with the meetings of several other scientific societies, at the University of Pennsylvania, Philadelphia, Pa., December 28-30, 1903. In the absence of the president and vice-president, the most recent past president, Dr. Erwin F. Smith, presided. Though not large in point of numbers the meeting

was in every respect one of the best in the society's history. The officers elected for the ensuing year were as follows:

President—Dr. G. T. Moore, of the Department of Agriculture, Washington.

Vice-President—Professor Clara E. Cummings, of Wellesley College.

Secretary-Treasurer—Professor W. F. Ganong, of Smith College.

The following new members were elected: Professor G. J. Peirce, of Leland Stanford University; Professor C. H. Shaw, of the Medico-Chirurgical College, Philadelphia; Dr. H. S. Conard, of the University of Pennsylvania. A committee, consisting of the new president, the secretary-treasurer and Professor D. S. Johnson, was appointed to confer with similar committees from the other botanical societies upon possible future affiliation or union of botanical societies.

The social features of the meeting were very enjoyable. They included a reception to the society by the Botanical Society of Pennsylvania and the Graduate Botanical Club of the university, in Biological Hall, Monday evening, December 28, luncheon tendered to the members of all the societies by the university on Tuesday and Wednesday, December 29 and 30, the smoker given by the local committee to all the visiting scientific men on Tuesday evening, December 29, the reception to the members of all the scientific societies by Dr. and Mrs. Horace Jayne on Wednesday evening, December 30, and many courtesies extended to the visiting members by members of the society resident in Philadelphia. On Wednesday afternoon the members of the society visited and were shown the Philadelphia Museums, on the special invitation of the director, Dr. W. P. Wilson, and later they visited Horticultural Hall.

The papers, of which abstracts follow, were all presented in full and discussed by the society, and they include every paper

which appeared upon the program. The abstracts are in every case by the author of the paper.

Experimental Morphological Investigations on the Abietineæ (illustrated by photomicrographic stereopticon slides): Professor E. C. JEFFREY, Harvard University.

The intention of the present communication is to show that experimental investigation is useful in determining the most primitive type of wood in the Abietineæ, a matter of considerable importance from the standpoint of the phylogeny of the Coniferales, since the identification of fossil species in this group rests at present very largely on the study of fossil woods. Among the existing genera of Abietineæ, *Pinus*, *Picea*, *Larix* and *Pseudotsuga* are characterized by the presence of resin-canals in their woody tissues, while *Cedrus*, *Abies*, *Pseudolarix* and *Tsuga* are without ligneous resin-ducts. The question arises, which of these two types of wood is the more primitive, and this question the author has attempted to settle from the experimental and comparative anatomical standpoints.

Abies may be taken as an example of a genus without ligneous resin-canals. In *Abies balsamea* resin-ducts appear in the wood as a result of mechanical injury and also as a result of the attack of parasitic fungi, producing 'witches' brooms.' In this and (all?) other species of *Abies* resin-canals are also normally present in the primary wood of the root. In certain species of *Abies* investigated in this connection, resin-canals are found not only under the conditions described for *Abies balsamea*, but also in the woody axis of the female cone and in the first annual ring of vigorous shoots. The two last-mentioned modes of occurrence of resin-canals are of special interest, for they must be regarded as

ancestral. It is now a well-established generalization that palingenetic features of anatomical structure are apt to persist in reproductive axes, and consequently the occurrence of ligneous resin-canals in the cones of certain species of *Abies* is good evidence that resin-canals were once a general feature of the wood in the ancestral species of the genus. This conclusion is strongly supported by the presence of resin-ducts in the *first annual ring only* of vigorous branches in certain species of the genus under consideration, for in this instance we have to do with the phenomenon of recapitulation, so well exemplified in seedlings of plants and in the young of animals. The conclusion is accordingly drawn, from both comparative anatomical and experimental data, that the genus *Abies* has come from ancestors possessing ligneous resin-ducts. Similar data in the case of the other genera usually described as lacking ligneous resin-canals, viz., *Cedrus*, *Pseudolarix* and *Tsuga*, lead to the same conclusion, that is, that these too have come from ancestry possessing ligneous resin-canals. As a further consequence of these observations the generalization is made that the older type of wood in the Abietineæ, is that in which resin-canals are present. The full significance of this generalization does not appear at the present time, but will be made clear as the remaining families of the Coniferales are described, from both the morphological and the anatomical standpoints.

Vegetative Reproduction in Certain Epiphyllous Lejeuneæ: Professor A. W. EVANS, Yale University.

The circular or oblong discoid gemmæ found in *Lejeunea convexistipa*, *L. accedens* and an allied new species were described. Each consists of a single layer of cells and is attached by its margin to a single projecting leaf-cell. Similar gemmæ have been described for the genus *Radula* and

also for other Lejeuneæ, but all of these differ in various points of detail. In the two Lejeuneæ referred to the gemmæ are shaped like a watch-glass and become inverted before germination takes place, in this way turning their concave faces toward the substratum. In the flat gemmæ of the undescribed species no such inversion seems to be necessary. In *L. convexistipa* the gemma retains its apical cell and upon germination gives rise directly to a leafy shoot. In *L. accedens* the gemma does not retain its apical cell and upon germination produces a flat protonema, from which the leafy shoot develops later. In the undescribed species both types of germination occur. This last plant is further remarkable because the protonema sometimes gives rise to secondary gemmæ, similar in all respects to those developed on the leaves. In this respect it resembles the peculiar genus *Metzgeriopsis*, of Java, in which the long-lived protonema bears both discoid gemmæ and leafy shoots.

Additional Notes on the Structure of the Starch Grain: Dr. HENRY KRAEMER, Philadelphia College of Pharmacy.

The author has continued his work on the study of the starch grain, and presented evidence to show (1) That the peripheral layer of the starch grain is a distinct membrane; (2) that soluble starch is present in the unaltered grain; (3) that iodine forms a definite, but easily dissociated, compound with starch; and (4) he gave a method for staining wheat starch grains. This method is as follows: To 0.500 gm. of starch add 2 c.c. of an aqueous iodine solution (containing 0.1 per cent. of iodine and 0.5 per cent. of potassium iodide); allow the mixture to stand 20 minutes, and then add 2 c.c. of a saturated aqueous solution of gentian violet; allow this mixture to stand from 12 to 24 hours, examining mounts of the material from time to time; when the grains

are satisfactorily stained, the mixture is transferred to a filter and the excess of stain is removed as quickly as possible by washing the magma with water; the material is then allowed to dry spontaneously, and mounted in Canada balsam, both the preparations and the dried material being permanent.

The foregoing method has features similar to the method used for demonstrating the so-called continuity of protoplasm in the vegetable cell-wall, and those who are interested in the latter subject will do well to compare their preparations with those of the wheat starch grain, made by the method just described.

On an Undescribed Thermometric Movement in the Branches of Woody Plants:

Professor W. F. GANONG, Smith College.

Some years ago the author observed a definite radial or in-and-out movement of the ascending branches of certain shrubs in winter, and undertook a systematic study of the movement, which appears not to have been investigated hitherto. By means of accurate measurements made with steel tapes from a central permanent tripod, the exact amount of the movement was determined for several shrubs and small trees. The results, when plotted, not only showed the movement to be real and of considerable amount, but also proved that the inward movement increases steadily after leaf fall till past midwinter, when an outward movement commences, long before the weight of the leaves begins to be felt. Furthermore, the important fact was discovered that the movement shows remarkable in-and-out secondary fluctuations, which are closely correlated with temperature changes. Experiments undertaken to determine the physical basis of the movement eliminated one possible cause after another until it was determined that it was correlated with the percentage of water in the stems, this

rising with a higher and falling with a lower temperature. It was proved that the weight of this water was insufficient to cause the entire movement though it does influence it, and evidence was given to show that the movement is probably due to the swelling of the parenchyma cells of cortex and pith under the osmotic absorption of the water permitted by the increased supply conducted up the stems in the periods of warmer weather. This swelling of the cells causes a straightening of the branch and hence the outward movement. The movement appears, therefore, to have no ecological significance but to be simply the incidental result of the physical and mechanical construction of the stems, but it is a new and interesting phenomenon. As it is an incidental result of, and closely dependent upon, temperature changes, the author has named the movement thermometric.

The Olive Tubercle (illustrated by stereopticon photographs and inoculated specimens): Dr. ERWIN F. SMITH and Mr. JAMES B. RORER, Department of Agriculture.

This disease was taken up because its bacterial origin has recently been called in question by Dr. Fischer. After describing the disease, which has been known for many centuries in Europe and has recently done much damage in California olive orchards, the experiments of Savastano and others were outlined, and then those undertaken in Washington. Tubercles were obtained from California. No difficulty was experienced in plating out bacteria or in finding them in the tissues on microscopical examination. They occurred abundantly in small irregular pockets. No fungi were present. From small knots pure cultures of a white bacterium were plated out, and with this organism the knots were reproduced. The olive trees used were small

ones propagated from older trees which have been in a hothouse of the U. S. Department of Agriculture for many years and which have always been free from this disease. The inoculations were made into young growing tissues (shoots) by needle pricks, using subcultures made from single colonies. In this way, using the right organism, knots have been produced on about fifty plants—in fact, on every one inoculated. The tumors began to appear within a few weeks and were well developed in two months. From these artificially produced knots, pure cultures of the original organism have been plated out in quantity a number of times, and have also been demonstrated *in situ* both stained and unstained. Young knots are also now developing on shoots recently inoculated with the organism plated out of the artificially induced knots. An equal number of check punctures made into the same plants, in shoots of the same age, healed promptly and did not develop any tumors. During the seven months covered by these experiments only one accidental infection has occurred. This recently discovered knot appeared on an inoculated shoot about fifteen inches below the punctures (where a tumor also developed), and the infection appears to have entered through a leaf scar. Old tumors may contain other bacteria, but these when inoculated do not produce the disease. The experiments fully confirm Savastano's statements respecting the bacterial origin of this tumor, but the parasite appears to be a white rather than a yellow organism. The knot is an enormous hyperplasia, the exciting influence of the bacteria extending far beyond their actual presence. Various tissues are involved in the tumor and they are much changed. A special paper will be devoted to this feature of the subject.

Bacterial Leaf Spot Diseases (illustrated by numerous stereopticon photographs): Dr. ERWIN F. SMITH, Department of Agriculture.

This paper was presented principally to call renewed attention to the fact that bacterial infection of plants through the ordinary stomata is not at all infrequent. Much remains to be done on these spot diseases, but a careful study of serial sections made through very young stages of spots occurring on several different plants show the epidermis unbroken and the enclosed bacterial masses lying in such relation to the stomata as at once to suggest such infection. No other avenue of infection is open. The plum leaf spot and the angular leaf spot of cotton have been studied within the year, particularly with reference to this mode of infection. In case of the spot disease of the larkspur, pure cultures of the bacterium have been plated out of the spots and the disease reproduced in blue hybrid *Delphiniums* and also in *D. ajacis* within a few weeks' time by simply putting pure cultures into sterile water and spraying this on the plants. The result of this disease is numerous sunken black spots on leaves and stems, with more or less distortion. The inoculations were made in Washington, some in the hothouse, others in a garden. The disease is known to occur naturally only in Massachusetts. The organism is motile, gray-white, nitrate-reducing, non-liquefying, and on agar in early stages the small circular surface colonies have a wrinkled structure easily demonstrated by magnification of twelve. It grows well at 30° C. but not at all at 37.5°. Its thermal death point is over 48° and below 49.10° C. It grows well in Uschinsky's solution. In agar the buried colonies are small. For this organism the name of *Bacillus delphini* is suggested. The other bacterial spot diseases mentioned as having come to the writer's

attention within the last two years were those of *Pelargonium*, soy bean, cow pea and ginseng. The latter is rather a yellowing and fraying of the leaf margins than a true spot. From the extremely numerous and quite characteristic spots on the soy bean leaves a yellow bacterium was isolated. This disease has been observed only in the vicinity of Washington.

A Fungus Infesting Stored Sugar: Dr.

C. O. TOWNSEND, Department of Agriculture.

The attention of the writer was called last summer to the abnormal condition of a quantity of granulated sugar stored in barrels. The sugar had become damp and unsalable, and could be restored permanently to its normal condition only by remelting and reworking. It was at first thought that this peculiar condition of the sugar was due to the presence of hygroscopic salts, but a careful examination showed that the sugar was practically free from salts of any kind. Upon placing a small quantity of the abnormal material under the microscope, numerous fungous threads and many round bodies resembling fungous spores were observed. When the material was plated out, three distinct fungi were found and pure cultures of each were made. As soon as these produced spores, quantities of normal sugar were inoculated and placed in damp chambers. In from two to three weeks the cultures made from one kind of spores—a *Penicillium*—showed the same characteristics that had been observed in the stored sugar, the cultures from the other fungi remaining unchanged for an indefinite period. It was found that the *Penicillium* spores would germinate and that the fungus would grow readily on sugar solutions of all strengths up to and including a fifty per cent. solution, and even on a saturated solution the spores germinated and produced new spores

in from six to eight days. The fungus grows readily on pure dextrose solutions, on solutions of C. P. maltose, and on all kinds of cooked vegetables, but it does not grow readily upon raw vegetables. The infested sugar becomes inverted, as shown by Fehling's test and by the fact that the polarization is reduced in all cases. Sometimes the reduction is as much as 99.8 to 92. The trouble may be prevented by storing the sugar in dry, well-seasoned barrels and keeping in a dry place.

Observations on the Structure of Dischidia, a Climbing Epiphyte from the Philippines: Dr. JOHN W. HARSHBERGER, University of Pennsylvania.

Dischidia sp. is a twining epiphyte native to the open areas in the province of Zambales, P. I. The plant, which early severs its connection with the soil, lives attached by horizontally placed adventitious roots to the surface of dead bamboo canes. It has two forms of leaves. The foliage leaves are thick and fleshy. The others are pitcher-shaped and about an inch and a half long. A second kind of adventitious root develops and grows into the pitchers, where it branches and forms an interlacing mass closely applied to the lower, inner surface of the saccate leaves. Inside the outer pitcher, a smaller one is developed, which represents the incurved apex of the highly modified leaf. A small black ant frequents the outer pitchers and carries into them decaying wood and leaf mold, from which the roots in the pitcher derive a constant supply of plant food. The details of the structure have been elaborated by Treub, Groom, Scott and Sargent for *Dischidia rafflesiana*, but the plant from the Philippines differs from this species in the following points: (1) The presence of long adventitious roots, which penetrate the pockets of decaying matter, collecting where a circle of bamboo branches arise; (2) the development of a

second pitcher within the outer one; (3) the shape of the outer pitcher, which is broader than long, and (4) the growth of the plant on dead bamboos instead of dead trees, as with *D. rafflesiana*. The presence of a purple color on the under surface of the pitcher the speaker believed to be correlated with the growth of the roots on that side and is not, as Groom claims, to shade the roots from too intense light. The absence of dead or partially digested ants would exclude the possibility of the pitchers being insect traps. In all probability they serve as chambers where water in the aqueous or gaseous state collects, and for the collection of humus upon which this asclepiadaceous plant primarily depends for food.

On the Excretion of Hygroscopic Salts in Frankenia and Statice: Mr. T. H. KEARNEY, United States Department of Agriculture.

Certain plants of arid regions, notably members of the Tamaricaceæ, Frankeniaceæ and Plumbaginaceæ, have long been known to possess the property of excreting salts in solution by means of epidermal glands of highly specialized structure. The excreted salts, in the cases recorded, are strongly hygroscopic. During the daytime when evaporation is intense, they exist as a dry granular deposit or as a thin continuous coating on the surface of the plant, while during the night they take up water. In the early morning the leaves and stems are often covered with drops of solution.

Observations were made upon *Frankenia grandifolia* in California and *Statice limonium* var. *Californica* in western Texas, both plants occurring in moist, strongly saline soils. In both cases chemical analysis showed that the principal constituents of the excretion were also the principal soluble constituents of the soil in which the plants were growing, although the propor-

tions differed sufficiently to indicate selective power on the part of the plant. In *Frankenia*, sodium and hydrochloric acid were the principal constituents of the excretion, while in *Statice*, calcium and sulphuric acid predominated. That the glands function actively in the process of excretion was demonstrated by brushing over portions of the leaf surface in living plants with an alcoholic solution of mercuric chloride. Areas thus treated nearly or quite ceased to excrete, while unpoisoned areas of the same leaf continued to excrete vigorously. Hence the 'salt glands' evidently belong to that type of hydathodes or water-excreting organs in which an active glandular function is involved.

What is the significance to the plant of this excretion of salts? Volkens, on the basis of a simple experiment performed upon *Reaumuria hirtella* near Cairo, concluded that the glands are able to take up water from the strong salt solution with which the surface of the plant is covered in the night and early morning, and thus supplement the roots as absorbing organs. Marloth and Haberlandt, however, have shown that Volkens's experiment does not necessarily prove more than a reduction of transpiration effected by the presence of the salt excretion.

A series of experiments upon *Statice* by the writer demonstrated that the absorbing power of the uninjured surface of the living leaves, even when immersed in pure water, is very small. Furthermore, concentrated salt solutions, applied either by immersing the leaf in them with the cut surface protected from contact with the solution or by placing a small amount of powdered calcium chloride on leaves kept in a saturated atmosphere, so far from giving up water to the leaves, actually withdrew a large amount from them, although not causing plasmolysis under these conditions. Addition of coloring matter to salt

solutions and to pure water in which leaves were immersed showed only a very slight penetration of the stain into the glands and other epidermis cells, and none into deeper-lying tissue. Incidentally, the gland cells were found to be much more resistant to plasmolysis than are other cells of the leaf.

Hence it is reasonably certain that in the case of *Statice*, at least, the epidermal glands are not absorbing, but merely excreting organs. Their importance to the plant may consist in their enabling it to rid itself of excessive amounts of salt, while secondarily the presence of the salt deposit on the plant is, perhaps, useful in reducing the rate of transpiration from its surface. The question whether under natural conditions the leaf is able to withstand the attraction exerted upon its water content by the solution tension of the excreted salts, remains unanswered.

The Cardinal Principles of Ecology: Professor W. F. GANONG, Smith College.

The paper comments upon the rise and promise of ecology, points out certain marked defects in its present methods, and discusses the direction it must take in order really to advance in the future. The ecology of the future must be based upon the exact study of environmental physics in correlation with physiological life histories of plants. Then the principles underlying the nature of adaptation are discussed, including the reality of adaptation, its evolutionary origin, its race (not individual) character, the necessary imperfection of all adaptation, its metamorphic phylogeny. This paper is to be published in full in SCIENCE.

Cinchona in Jamaica as a Botanical Station (illustrated by stereopticon photographs): Professor D. S. JOHNSON, Johns Hopkins University.

Cinchona Station, recently visited by the speaker, is located on a spur running south-

ward from the Blue Mountain chain. It is 4,900 feet above sea-level and has a climate that is comparatively dry, cool and stimulating. On the plantation at present are a well-built residence, several buildings fit for laboratories, a greenhouse and a rather extensive garden. The latter contains many introduced alpine and temperate-climate plants from many parts of the globe. On the remaining 20,000 acres of the plantation, and in the surrounding regions, are to be found many types of vegetation, varying from the dense forest of the mountains and of the deep river valleys, through many types to the xerophytic vegetation of the hills and plains south of the Blue Mountains.

The rich and varied flora, delightful climate, equipment and ready accessibility from all the Atlantic ports of the United States, make together a series of advantages such as probably no other location in tropical America possesses.

The Influence of Differences in the Electrical Potential on the Growth of Plants: Professor G. E. STONE and Mr. N. F. MONAHAN, Massachusetts Agricultural College.

For many years the idea has prevailed that atmospheric electricity exerts an influence upon plant growth. It is known that vegetation frequently becomes charged with electricity to quite an extent, also that during thunder-storms the potential of the air is likely to be high, and frequently changes from positive to negative.

Observations made in our laboratory have shown that at a distance of thirty feet from the ground the air is charged positively about 90 per cent. of the time. The differences in potential between the earth and the air ranged in voltage from 75 negative to 300 positive. Some of the earlier experiments, carried on in a limited way, seemed to show that when atmospheric

electricity was withdrawn from a plant growth was retarded. These earlier experiments were conducted by surrounding plants with wire cages, thus screening them, as it were, from atmospheric electricity. A series of experiments were made for the purpose of ascertaining whether any relationship existed between the growth of outdoor plants and the differences in atmospheric electrical potential as obtained by frequent measurements of the plants, and by the aid of a Thompson self-recording electrometer. These experiments were not, however, for various reasons, very satisfactory.

Subsequent experiments were, therefore, conducted in a large glass case which was charged to various potentials, and for this purpose potted tomato plants, about three inches high, corn seedlings and molds, such as *Mucor* and *Phycomyces*, were employed. Potentials varying from 100 to 2,000 volts were made use of; the latter appeared to act disastrously in many cases. Small tomato plants responded most favorably under a potential of about 50 volts, which is not far from the optimum for tomato plants of this size. *Mucor* and *Phycomyces* responded most favorably to lower potentials, and the effects of high potentials were particularly disastrous to them. The latent period had a duration of from fifteen to twenty-five minutes.

The experiments with various seeds showed that germination was greatly accelerated, although in the case of old seeds there was no evidence that electrical stimulation resuscitated life.

The most essential facts brought out were that there exists a minimum, optimum and maximum potential corresponding with the nature, size and degree of development of the plants, and that when plants are grown under conditions in which the influence of atmospheric electricity is eliminated, they exhibit a marked response to electrical

stimuli. The potential which induced this response is within the range of that usually found in nature. There is every reason to believe that electricity acts as a stimulus to plants in nature, and undoubtedly has much to do with their development and configuration.

The Effect of the Presence of Insoluble Substances on the Toxic Action of Poisons: Dr. RODNEY H. TRUE and Mr. C. S. OGLEVEE, Department of Agriculture.

During the summer of 1903, at the Marine Biological Laboratory at Woods Hole, Mass., the authors undertook a study of the effect of insoluble substances on the poisonous action of solutions of electrolytes and non-electrolytes. A modifying action has been observed by Nägeli in the case of algæ, and it is a common observation that poisonous solutions applied to said cultures are not as effective as in even more dilute water cultures. In the experiments here summarized, mercuric chlorid, silver nitrate and copper sulphate have received attention as representative electrolytes; and phenol, resorcinol and thymol as representative non-electrolytes. Carefully prepared sand, filter paper and paraffine were used as insoluble bodies. The test reaction was the growth rate of the primary root of *Lupinus albus* seedlings, made during a period of twenty-four hours of exposure to the solutions in question. The toxic substances were made up in strong stock solutions which in these experiments were diluted to concentrations sufficiently toxic to exert a marked effect on the growth of the plants. In the case of the heavy metals above mentioned, a decided acceleration in growth was seen to accompany the presence of the insoluble substances in the solution. No such acceleration followed the introduction of the insoluble substances into the check cul-

tures in distilled water, nor did any marked result appear.

In the case of the copper sulphate solutions, the action of the insoluble bodies seemed to be especially well marked. In many instances the introduction of 40 grms. of sand into 150 c.c. of a given solution was seen to accelerate the growth rate from a few millimeters in the check solution containing the copper salt alone to a growth rate nearly normal for the distilled water used in making the solutions. The modifying action of the insoluble substances was found to vary widely, according to the quantity used, assuming that the volume and concentration of the solution are constant. The following instance is typical:

35,000 liters solution.	2.0 mm.
" + 40 grms. sand.	7.0 "
" + 80 " "	10.0 "
" + 120 " "	16.0 "
" + 160 " "	13.0 "
" + 200 " "	12.0 "
Distilled water.	12.0 "

In this case growth was practically at a standstill in the copper solution. The introduction of 40 grms. of sand gave a growth rate equal to one half of the growth rate in distilled water. The addition of further sand resulted in a growth rate of increasing rapidity, until when 120 grms. were added a maximum was reached. Further addition of sand was followed by a decreased rate of growth, finally approximating that of the check.

Unpublished investigations were cited in which it was shown that a somewhat similar situation results when a series of progressively diluted solutions of the copper sulphate is tested by the above method with the lupine radicles. In concentrations of toxic activity, growth is quickly suppressed. As the solution is diluted more and more, the growth rate increases, until a rate characteristic of distilled water is reached. In the action of the copper sulphate solution

the phase characterized by the depressed growth rate may be termed the depression phase. This is succeeded, at a given concentration, by a growth rate like that of the check, the copper being neutral in its action. Upon further dilution the radicles are found to grow more and more rapidly until at a definite concentration a maximum rate is reached, which much exceeds that of the check. Further dilution at this point is followed by a falling off in the rate of growth until at a definite concentration the solution is so weak in its action as to leave the medium equivalent to so much distilled water. The first neutral phase is thus seen to be followed by a phase of pronounced acceleration of growth rate. This acceleration rises to a maximum and declines to a second neutral phase of indefinite extent covering all greater dilutions.

From these experiments it seems clear that the presence of insoluble substances exerts an effect closely paralleling that of simple dilution. By comparison with the growth curve obtained in increasingly diluted solutions, it is possible to indicate what amount of copper remains in the free solution unremoved, physiologically speaking, by the solid.

Various investigators have shown that gases are condensed over surfaces of solid bodies, the layer of gas in contact with them containing a much greater concentration of molecules than is contained by a like volume of free space. This has been extended to solutions. It has been shown that the walls of the containing vessels or solid particles placed in the solutions condense substances from aqueous solutions. It has been found that this process, known as adsorption, is largely dependent upon the nature of the adsorbing solid and on the amount of surface it offers to the solution. The adsorptive activity of sand, filter paper, charcoal and other bodies has been demonstrated. These bodies are all

wetted by the solution from which molecules are adsorbed. In the investigations here reported, not only were solids used which were wetted by the aqueous solution, but also paraffine, in the case of which a different type of contact exists between the solid and the solution. Perhaps no contact exists in the sense of a relation so intimate as to bring the molecules of the dissolved substance into actual contact with the paraffine. The contact surface between the paraffine and aqueous solution may, perhaps, be regarded as comparable to a surface film which bounds the contact of the solution with air. Whether or not an actual air film is present between the paraffine and aqueous solution, the presence of paraffine in solutions of the toxic agents was seen to exert a marked effect, perhaps as great as that of sand. It is probable, therefore, that the generalization of the physical chemists concerning adsorption may be extended so as to include among adsorbing surfaces those films which in solutions surround bodies which are not moistened by the solution. Physical investigations on this point are lacking.

It is regarded by the authors as probable that the insoluble substances used in experiments here summarized act as adsorbing surfaces for molecules or ions of the poisonous substances used, the number of molecules or ions thus adsorbed being, at the extreme dilution here cited, sufficient to remove a very considerable proportion of the ions or molecules from the free solution. These are considered as collected over the surfaces of the insoluble substances or films present in the solutions in a layer molecularly much denser than the free solution. In bringing about this redistribution of molecules or ions, the free solution, when equilibrium has been established, is necessarily much weakened in ions or molecules. This affects the solution much like the addition of water, bringing about a

decreased number of molecules in a given volume of the free solution. Hence the close parallel seen between the conduct of the radicles in solutions containing increasing quantities of insoluble substances and in progressively diluted aqueous solutions.

Concerning the relation of the poisonous substance to the adsorbing surfaces, a further point is developed. In the solutions of the heavy metals already referred to, complete ionization is probable, and a possible electrical relation might be supposed to exist. This is, however, not necessarily so, since in solutions of thymol, a non-electrolyte, a similar action was seen, indicating that the electrical conditions in the solution play no necessarily important part.

The bearings of this work on practical problems of plant physiology are very many. It is impossible to argue from the behavior of plants in water cultures to their behavior in soil, since in the soil adsorption is seen in a high degree of efficiency, where films and insoluble substances bring about a situation entirely different from that seen in a free solution. Hygroscopic water, so called in works on plant physiology, is doubtless to be regarded as an adsorbed solution governed by the laws of adsorption. The recognition of this relation would render physiological discussions bearing on soil conditions much clearer. The stock experiments in elementary plant physiology demonstrating that solutions poured from clean sand come out weaker in molecules than they go in, is to be explained as an example of *adsorption* rather than *absorption* by the soil. The importance of adsorption physiologically with reference to the root system, especially the root hairs, is seen when one bears in mind the fact that in the ground water those portions of the solutions are richest in molecules which are adjacent to insoluble substances or films. Many relations of a plant to its substratum are affected by this con-

dition of affairs which can not be pointed out here.

In the interior of the plant, with the large amount of wall surface, and, in case of storage cells, of solids like starch grains, etc., adsorption may also play a considerable rôle. It seems probable that in addition to osmosis and diffusion the distribution of dissolved materials in the plant may be very largely affected by adsorption. It seems probable that this form in which energy is exerted may play a part of unsuspected importance in the plant. Not the least important, perhaps, may be the effect of adsorbing surfaces in bringing about at points of greatest activity an increased concentration of the raw materials needed in connection with these processes.

The efficiency of bacteria as adsorbing bodies is probably great and the physiological activity of minute organisms may be in part due to the energy of adsorption, which brings about a concentration of the medium at the surfaces of the organisms, making possible the characteristically active metabolism even in dilute media. Further experiments along the various lines here indicated are in progress.

An Exhibition of Several New Precision Appliances for Investigation and Demonstration in Plant Physiology: Professor W. F. GANONG, Smith College.

It was pointed out that the development of makeshift or improvised apparatus for plant physiology has gone as far as practically possible, and farther than is educationally and scientifically desirable, and that the next movement in this subject should be towards the development of normal apparatus, pieces which will be manufactured for the specific work to be done or topic to be studied, which will perform that work with accuracy and with convenience and economy of time in manipulation, and which will be obtainable from the supply

companies precisely as physical and chemical appliances are. Several new pieces, which have been invented by the exhibitor, were then exhibited. They are to be manufactured and offered for sale under his supervision by the Bausch & Lomb Optical Co. The pieces exhibited included (1) a new clinostat, very compact, capable of working in any position whatsoever, powerful enough to carry a five- or six-inch pot in any position, needing winding but once in two days; (2) a new portable clamp-stand for apparatus, with handles for carrying it about, levelling screws, special positions for the rods, and new special clamps; (3) an autographic transpirometer, which can be used with any balance sensitive to a gram, and which records precisely on a drum the transpiration of a plant for a week; (4) a new photosynthometer, by which the exchange of gases in photosynthesis may be exactly and conveniently measured, either for demonstration of the processes to classes, or in investigation for particular plants; (5) a new leaf clasp chamber for use wherever it is desired to apply patterns, cobalt chloride paper or other object exactly matching upon the two faces of the leaf; (6) a new leaf chamber for holding a leaf under approximately normal conditions perfectly flat in any desired position while studying various phases of photosynthesis, etc. The apparatus is all mechanically unexceptionable, and it was announced that other pieces are in preparation and more or less advanced towards completion.

On the Spores of Certain Coniferæ: Professor W. C. COKER, University of North Carolina.

It has been long known that the mature pollen grain of a number of conifers contains no sterile prothallial cell. The possibility still remained, however, that one or more such cells might be cut off early in

development and, by complete absorption, leave no trace in the fully mature grain. For the determination of this point the following forms were examined: *Cupressus* (four species), *Taxus baccata* and four varieties, *Juniperus* (two species), *Chamaecyparis* (five species), *Callitris* (one species), *Cryptomeria japonica*, *Thuja orientalis*.

The results showed that in all these forms there was no prothallial cell formed at any time in the development of the pollen. Ovules of *Thuja orientalis* and *Taxus baccata* were examined to determine the number of potential megaspores formed. It was found that in *Taxus* there are four produced—these lying, as a rule, in a row, and the lower developing into the prothallium.

In *Thuja* there are also four megaspores produced, but they are arranged, not in a row, but in nearly regular tetrad form, differing in this respect from all other gymnosperms so far studied.

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SCIENTIFIC BOOKS.

STILL ANOTHER MEMOIR ON PALÆOSPONDYLUS.

Palæospondylus, like Gloster, seems to have been born to bite the world—for in its few short years of morphological nurture it has succeeded in causing trouble to an amazing degree. And we venture to use an Elizabethan simile with a clearer conscience, since in the latest time we are told that this obscure little fossil is not to be looked upon as a toothless lamprey, but rather as a shark. We must none the less admit that it gives us a sense of sadness to learn of the new rôle of the fish, since this reduces by one the novelty of its being assigned to still other groups, for we recall that the number of groups is well nigh exhausted. There remains in fact but one more of the major groups of aquatic vertebrates to which it can possibly be assigned. It has

already been reckoned among arthrodires (? ostracophores), lampreys, teleostomes (*Alilis*), sharks, lung-fishes, even amphibians. To make our list complete, we have now only to assign it to holocephals. And lest some one anticipate us, we may as well regard it as a chimæroid at this time, and in evidence of this refer to its continuous dorsal fin, 'protocercal' tail, ring vertebrae, elaborate nasal cartilages, huge head—and we might find other similarities if we tried hard enough. Seriously, though, such a state of affairs is a reproach to modern morphology, that with all our extensive knowledge of fishes we are not able to come to a better understanding of our Devonian 'lamprey.' For if the remains of *Palæospondylus* are so poorly preserved that they cannot be definitely described, why do we continue to add papers to the troublesome literature? The only possible excuse is that the creature is seductive, full of suggestions as to the origin of the gnathostomes, and the mode of evolution of jawless vertebrates.

During the past summer I happened to see in South Kensington some of the elaborate models of *Palæospondylus* which Professor Sollas and Ingerna B. J. Sollas have been preparing. These are built up of thin wax plates, after the method of Born, the sections, however, having been outlined at a series of levels (differing in thickness for about .1 +, .025 mm.) as the fossil was carefully ground down. And I examined the models with great interest, wondering whether by a new method there could be gained facts which would help to solve the present puzzle.

In their complete paper* the authors now discuss the results obtained from a series of their models, of which no less than eight have been prepared. They describe the characteristic parts of the fossil, christening some of them with rather difficult names such as 'hemidome,' 'tauidion,' 'ampyx,' 'gammation' and 'pre-gammation.' But the structures described which interest us especially are the 'branchial arches,' four in number, showing

* 'An Account of the Devonian Fish, *Palæospondylus gunni*, Traquair,' by W. J. Sollas and Ingerna B. J. Sollas, *Phil. Trans.*, Series B, Vol. 196, pp. 267-294, pls. 16 and 17.