determines the period and wave form of the oscillations.

This investigation is being continued.

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ON WALDEN-INVERSION

IN connection with the problem of Walden-Inversion, it is important to know whether the change in the polarity of a group attached to the asymmetric carbon atom is accompanied with a change of direction of optical rotation when the change of polarity is accomplished without resorting to substitution. It is realized that the result may depend on the polarity of the other elements attached to the asymmetric carbon atom. A systematic study in this direction is possible on substances of two groups; first on derivatives of secondary carbinols of the type R_1CHOHR_2 and second, on the derivatives of the primary alcohols of the type $\genfrac{}{}{0pt}{}{R_1}{R_2}\!\!>\overset{H}{C}\!-\!CH_2OH$. In both groups of substances the radicles R_1 and R_2 may be varied infinitely and in both of them, the polarity of one group may be changed without substitution. Both these groups of substances are now under investigation in our laboratory. Results have already been obtained on a derivative of the first group of substances.

Laevo-methylhexylcarbinol was converted by substitution into dextro bromide; this, in its turn, again by substitution into laevo-mercaptan and the latter by oxidation (without substitution) into dextro-sulfonic acid.

$$\underset{\text{laevo}}{C_6H_{13}CHOHCH_3} \rightarrow \underset{\text{dextro}}{C_6H_{13}CHBrCH_3}$$
$$\rightarrow \underset{\text{laevo}}{C_6H_{13}CHSHCH_3} \rightarrow \underset{\text{dextro}}{C_6H_{13}CHSO_3HCH_3}.$$

Thus, in this group of substances, the change in polarity, brought about with or without substitution on the asymmetric carbon atom, leads to a change in the direction of rotation.

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THE RELATION OF CLIMATIC CONDITIONS TO THE SALT-PROPORTION REQUIREMENTS OF PLANTS IN SOLUTION CULTURES

ALTHOUGH it has been known for more than sixty years that many forms of higher green plants may be grown to maturity with their roots in an aqueous solution of a few inorganic salts, it is only in the last decade that attention has been seriously directed to the study of the relations that prevail between the nature of the solution thus used (kinds of salts, salt proportions and total salt concentration) and the amount and kind of growth exhibited by the plants. Since the publication of the earlier work in this field by Schreiner and Skinner, Tottingham, and Shive, many experimental studies have been made, by different investigators, with the aim of throwing light on this complex relation. Great difficulty has thus far been encountered, however, in obtaining satisfactory agreement or consistency, even by the same experimenter, between the results of two or more experiments planned and executed so as to be as nearly alike as possible with respect to the plants and solutions used. Similar difficulty is frequently encountered in many other lines of biological experimentation, whether with plants or animals.

In experimentation dealing with the influence of external conditions on the growth of any kind of plant, it is of course essential that all the individual plants of the same experiment should be as nearly alike as possible (in variety, race and physiological condition) at the outset of the experiment, and also that this same degree of similarity should obtain among all the plants of several experiments that are planned to give comparable results. But we can not be at all sure that variability among the plants with which the experiments are set up is satisfactorily cared for by employing seeds of a pure line, selecting them for uniformity of weight, germinating all seeds in the same way, and selecting the seedlings for likeness in size, robustness, and so forth. Even after taking all feasible precautions in this respect, internal variability is generally found to be far from negligible. The difficulty can of course be largely overcome by employing a great number of duplicates in every test. The number of duplicates needed naturally depends on the degree of precision required in the results and on the degree of internal variability that persists in the plants after care has been exercised in selection, and other experimental details. By using a sufficient number of duplicates, all cultures in a comparable series, whether in the same or in several experiments, may be made to represent the same quality and range of internal variability in the plants. It may be added that the plants at the beginning of an experiment should be adequately described. This is necessary in order that it may be known for just what sets of original internal conditions the experimental results may be considered as applicable, in order that the experiment may be repeated later, and in order that subsequent experimentation in general may be carried out so as to be comparable with earlier tests. Statistical methods are requisite for finding and stating what kinds and ranges of variability persist in the original plants. Also, statistical treatment of the experimental results helps to indicate the relative degrees of significance to be assigned to the several resultant growth differences that are to be compared.

Assuming that the internal conditions of the plants at the outset of an experiment have been sufficiently well considered and cared for, the environmental complex of conditions deserves at least an equal degree of attention. In any experiment or series of experiments the influential features of the environment may be conveniently grouped in two categories: (1) Those that represent the variables to be specially studied, and (2) those representing the rest of the environmental complex. The influential conditions of the first category are assumed to be adequately known; they are the conditions that are purposely made to differ in certain known ways, from culture to culture. In water-culture experimentation these are usually the chemical or osmotic characteristics of the solutions tested. In studies on the physiological balance of salts in the solution about the roots, the several different solutions are usually prepared so as to supply just those chemical elements that are essential to the plants, and they are made to differ in certain known ways with regard to the relative partial concentrations of the salts. The salt proportions, or ion proportions, are the acknowledged and prearranged variables in such studies.

For an ideal experiment or experiment series the remaining influential environmental conditions (our second category) should of course each be the same for all cultures, and they should be as thoroughly known and as definitely described as are the acknowledged variables. Here belong the influential aerial conditions as well as those of the influential solution conditions that are not included in the first category. Among these solution conditions may be the kinds of salts used, the osmotic properties of the solutions tested, the rate of renewal of the solutions in the culture vessels, and so forth. Several solutions may be prepared to contain the same salts and to have the same osmotic value and they may all be renewed in the same way, while they differ in definite and known ways as to their salt proportions. These solution features are readily controlled to a high degree of precision, but the aerial features are not generally artificially controlled, nor are they quantitatively well known in most experimentation on the salt nutrition of higher plants.

Aside from the features of the environment that are readily controllable in nutrient solutions, the environmental influence on plant growth can as yet be analyzed only in a very superficial way. It is not yet feasible even to prepare a somewhat detailed list of the features that should usually be taken into account in culture studies such as we are considering, and the problem of controlling, or even that of measuring them is thus far almost untouched. A number of experimenters have attacked various separate phases of this problem and marked advances are being made, but the time is not yet ripe for any attempt to set up an experiment on the salt nutrition of higher plants with all the influential non-solution environmental conditions as well controlled and known as are the chemical and osmotic conditions of the solutions and the internal conditions of the culture plants at the beginning of the test. Nevertheless, it is of course easy to arrange a single experiment so that all cultures will be subjected to very nearly the *same* fluctuations in the aerial surroundings during an experiment period, even though these fluctuations are quite unknown. The rotating table introduced by Shive usually accomplishes this very satisfactorily, and Duggar's planetary rotation of each culture vessel on the main table is a still further refinement. The great difficulty arises when two comparable experiments are to be carried out on separate rotating tables or, more especially, at different times. In studying inconsistent results secured from two separate experiments in which the internal conditions of the original plants and the chemical features of the solutions used have been sufficiently well cared for, one thinks first of the climatic conditions as among those that may not have been effectively alike in the two cases. We have in mind especially air temperature, the temperature of the solutions in the culture vessels, the evaporating power of the air (including water vapor-pressure deficit and wind velocity, and the complex conditions of illumination. Other non-solution conditions may be influential, but these climatic ones are surely not to be generally neglected in solution-culture experiments. This suggestion has been advanced by several writers in this field.

We have recently completed some experiments that were planned to throw a little light on the question of how great may be the climatic differences between two experiments without rendering the results incomparable with reference to the problem of salt proportions. It seems safe to suppose that the time may eventually come when the relative physiological values of several salt solutions of the sort here considered may be determined for a given kind of higher plant, for a given period of its development, and for a given set of non-solution conditions, with considerable assurance that the same relative values may be repeatedly demonstrated by repetitions of the experiment at other times and places. Until this can be actually achieved, progress in this field must be mainly confined to studies aiming towards improvement of experimental methods and to generally vague or very special conclusions as to the real meaning of the concepts of physiologically balanced solutions, toxicity, salt antagonism, the influence of temperature conditions, and so forth. Our experimental results may be of some use in preparing the way for what may be thought of as rather satisfactory standard demonstrations of the principles of the salt nutrition of higher plants. Plant physiology seems to have a long way to go before this simple ideal may be achieved, but it may be that the way will be traversed more rapidly than the most optimistic would dare predict.

We hope to present a fuller account of our experiments elsewhere, and the present report is only a preliminary summary of some selected features. We are indebted to Mrs. Helen M. Trelease for valuable assistance in the experimentation.

Eight very different solutions were tested simultaneously under two diverse sets of climatic conditions, the first climate being that of an ordinary greenhouse and the second that of a basement room with nearly constant temperature and with no light excepting that supplied by five 200-watt "Mazda C" electric lamps, which operated continuously. The experiment was carried out from February 6 to March 6, 1923, and it was repeated from March 11 to April 8, 1923.

"Marquis" spring wheat of a pure line was employed.[1] Selected seeds each weighing between 32.5 and 37.5 mg were germinated under largely controlled conditions, and selected seedlings (measuring between 4 and 5 cm in length of top, in the first experiment, and between 4.5 and 5.5 cm, in the second experiment) were mounted in cork stoppers, five seedlings in each stopper. The culture vessels were 3-gallon, cylindrical, glazed earthenware jars, nearly filled with solution and covered with a paraffined Portland cement disk having eight circular openings, in which were set the stoppers supporting the plants. There were forty seedlings in each culture. The cultures of each set stood near the edge of a continuously rotating table.

Each of the culture solutions had an osmotic value of approximately 1.00 atmosphere for a temperature of 25° C. The volume-molecular salt proportions of the three main salts (KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$) are given for each solution in the accompanying table. It will be noted that solution IV had equal proportions of the three main salts and that the several sets of salt proportions were selected so as to give, in all, a rather wide variation from this equality in all three directions. In addition to the three main salts each solution contained a small amount of ferrous sulphate, the partial concentration of this salt being 0.000005 M for the first seventeen days and 0.000017 M for the remaining eleven days. The solutions were all renewed every two days, each plant being thus supplied with solution at the average rate of about 131 cc per day.

At the end of the growth period (28 days) the top dry weight of each individual was determined. The means of the yield values, with their probable errors, are given in the table, in which each mean yield is followed by a number (relative value) in parenthesis, showing the mean as a percentage of the corresponding mean for solution VIII.

Considering the two sets with continuous illumination, we see that every solution gave a somewhat lower actual yield mean for the second experiment than for the first, which may possibly be related to slight differences between the two climatic complexes for the two periods. Each of the two corresponding relative values (in parenthesis in the table) may be considered as about the same, however. Furthermore, solution VIII, here considered as a control or standard, gave eight ninths as great a mean for the second experiment as for the first. It appears that the non-solution conditions of the second continuously illuminated set did not differ sufficiently from those of the first to produce very serious corresponding differences in the ways in which the plants reacted to the several solutions. For both sets the highest three means are, in descending order, for solutions VIII, IV and II, and the lowest three are, in ascending order, for solutions I, V and VII. On the whole the second experiment with continuous illumination seems to have been a very satisfactory duplication of the first.

The climatic differences between the two greenhouse sets must have been much greater (considering the seasonal difference and the probable direct influence of sunlight) than those between the two continuously illuminated sets, and this supposition corresponds with the fact that the standard solution (VIII) gave a mean yield 36 per cent. greater for the second experiment than for the first. A similar difference in actual yield means is shown for every one of the other solutions. When we consider the relative values, however, it is seen that the two for each solution are generally nearly the same. We are consequently brought to the conclusion that, although the second set of greenhouse conditions was uniformly much more favorable to growth than was the first set, yet the climatic difference between these two sets was not of a nature and magnitude sufficient to bring about any serious differences in the relative physiological values indicated for the several solutions. For these sets the highest three means are, in descending order, for solutions VIII, II and IV (both sets), and the lowest three are, in ascending order, for solutions I, VI and III (first set) or I, III and VI (second set). It appears that as far as the *relative* physiological values

[1] Marquis, Saskatchewan, No. 70, Selection No. 313, supplied by the University of Saskatchewan, through the kindness of Professor Manley Champlin.

of the several solutions are concerned, the second greenhouse experiment must be regarded as a very satisfactory duplication of the first.

The points thus far mentioned seem to indicate that satisfactory duplication of both *actual* and *relative* values may be expected in such duplicated experiments as these, if the climatic conditions are nearly enough duplicated—a little more nearly than was the case in our two continuous-illumination tests; and that just as satisfactory duplication of the *relative* physiological values may sometimes be secured even when the climatic complex of the second test is markedly different from that of the first—different enough to bring about a pronounced corresponding difference between the two *actual* yields for each solution. With a properly chosen difference between the two climatic complexes, we must suppose, however, that *both* actual and relative values must differ seriously. Support for this supposition is met with when we compare either greenhouse set with either continuously-illuminated set in our experiments.

Scrutinizing the two sets of values for the second experiment, we see that the standard solution (VIII) under greenhouse conditions gave an *actual* mean yield 2.31 times as great as was the corresponding mean for continuous illumination, and a similar relation holds for these two actual mean yields for each of the other solutions. On the other hand, outstanding differences are manifest between the two *relative* values for each of the four solutions, I, III, V and VI; the relative physiological values given for solutions I and V are definitely lower for continuous illumination, while those given for solutions III and VI are definitely higher. Nevertheless, the two sets of climatic conditions gave about the same relative values for each of the solutions, II, IV, VII and VIII. The great climatic difference here dealt with was without significant corresponding difference in the relative physiological values indicated for the four last-named solutions by the biological test. On the other hand, solutions I, V and VIII were much more nearly alike in physiological value when employed under greenhouse conditions than when employed in our basement room, and solutions III, VI and VIII were much more nearly alike when used in our basement room than when used in our greenhouse.

Notwithstanding the pronounced climatic difference between our greenhouse and our basement room, and although the former gave markedly larger actual yields than did the latter, yet the best three solutions are the same under both sets of conditions; as has been mentioned, they are, in descending order, solutions VIII, II and IV for the greenhouse climate and VIII, IV and II for the continuous-illumination climate. Similarly, solution I is poorest for both sets of climatic conditions. The second and third from the poorest are different for the two climates, however, being solutions VI and III (or III and VI) for the greenhouse and solutions V and VII for the basement room. The two medium solutions are numbers V and VII for the greenhouse and numbers III and VI for the basement room.

The general indications of these tests seem to be clear. If a number of markedly different nutrient solutions are repeatedly compared by biological tests made under different climatic complexes, the relative physiological values assigned to the several solutions may be either the same or more or less different for the several tests, according to the nature and magnitude of the climatic differences dealt with. It does not seem safe, in the present state of our knowledge of these things, to attempt to determine, with any

SALT PROPORTIONS OF NUTRIENT SOLUTIONS AND CORRESPONDING MEAN DRY WEIGHTS OF TOPS, WITH THEIR PROBABLE ERRORS; EACH NUMBER IN PARENTHESIS SHOWS THE RELATIVE YIELD EXPRESSED AS A PERCENTAGE OF THE CORRESPONDING YIELD FOR SOLUTION VIII.

Solution Number	Volume-Molecular Proportions of 3 Main Salts (KH_2PO_4:$Ca(NO_3)_2$:$MgSO_4$)	First Experiment (February 6 to March 6, 1923)		Second Experiment (March 11 to April 8, 1923)	
		Greenhouse Set	Continuously Illuminated Set	Greenhouse Set	Continuously Illuminated Set
		mg.	*mg.*	*mg.*	*mg.*
I	5 : 5 : 90	77.3 ± 1.1 (71)	37.1 ± 0.6 (51)	98.9 ± 1.3 (67)	29.4 ± 0.4 (46)
II	5 : 47.5 : 47.5	108.5 ± 1.3 (100)	66.5 ± 1.3 (92)	140.0 ± 1.5 (95)	59.9 ± 1.1 (93)
III	5 : 90 : 5	84.7 ± 1.2 (78)	64.3 ± 1.1 (89)	103.8 ± 1.5 (70)	59.4 ± 0.9 (93)
IV	33.3 : 33.3 : 33.3	104.2 ± 1.4 (96)	71.2 ± 1.2 (98)	136.7 ± 1.8 (92)	63.8 ± 0.9 (100)
V	47.5 : 5 : 47.5	90.5 ± 1.5 (83)	39.8 ± 0.7 (55)	120.7 ± 1.6 (81)	34.9 ± 0.7 (54)
VI	47.5 : 47.5 : 5	82.1 ± 1.2 (75)	66.5 ± 1.4 (92)	107.5 ± 1.5 (73)	58.8 ± 0.8 (92)
VII	90 : 5 : 5	88.0 ± 1.1 (81)	51.3 ± 1.0 (71)	125.9 ± 1.7 (85)	50.6 ± 0.7 (79)
VIII	50 : 18 : 32	108.9 ± 1.2 (100)	72.3 ± 1.1 (100)	148.1 ± 1.7 (100)	64.1 ± 0.7 (100)

considerable degree of precision, the comparative physiological values of different salt solutions without being able to describe adequately the climatic conditions under which the tests are made.

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THE AMERICAN PSYCHOLOGICAL ASSOCIATION

The Psychological Association met at the University of Wisconsin December 27 to 29. This is the first time the association has met at Madison. The choice of this place of meeting, although it is somewhat out of the direct line of travel, was justified by the size and enthusiasm of the assembly. The registration up to Friday noon was 120, which is not far short of the registration at recent meetings. Still more significant was the wide geographical distribution of the residence of those in attendance. Of the papers presented, fifteen were by members in the Alleghenies or east of them, six by members in the Rockies or west of them, making a total of twenty-one. Psychologists living between the Rockies and Alleghenies contributed the same number—twenty-one. When it is considered that there must always be some preponderance of papers from the immediate neighborhood, these statistics indicate the genuinely national scope of the meeting. The choice of Madison as a meeting place this year acquires significance from the fact that Dr. Jastrow is now completing the thirty-fifth year of his professorship at the University of Wisconsin—the longest consecutive service of a professor of psychology in the United States.

The next meeting of the association will be held at Washington, D. C., on December 29, 30 and 31, 1924, in conjunction with the quadrennial convocation of the American Association for the Advancement of Science. Dr. L. L. Thurstone is local representative.

The president of the association for next year is Dr. G. Stanley Hall, famous as president of Clark University and as leader in the study of the psychology of childhood and youth. Only once before has the same man been elected twice to the presidency, the former case being that of William James. The Psychological Association was founded in Dr. Hall's house thirty-two years ago, and he was its first president.

The other officers who were elected at this meeting were as follows: New members of the council, R. Pintner and A. T. Poffenberger; representatives of the council of the American Association for the Advancement of Science, R. M. Yerkes and W. V. Bingham; representatives on the Division of Anthropology and Psychology of the National Research Council, E. L. Thorndike and Knight Dunlap.

The dues of the association were raised to $5.00. A committee was authorized to report at the next meeting on the desirability of constituting a second type of membership with less rigid requirements than those in force for full members. The council is developing plans for a very systematic survey of prospective members, and in accordance with these plans applications for election at the ensuing meeting must be in by March 15. Twenty-two new members were elected at the recent meeting.

Announcement was made of the meeting of the British Association for the Advancement of Science at Toronto, on August 6 to 13, 1924. American psychologists are invited to become members for the meeting and to contribute papers. A good attendance of British psychologists is expected. Professor Wm. McDougall, formerly of England, now of Harvard, is chairman of the psychological section, Section J.

The papers which were presented at the meeting were, on the whole, of much interest. Two novel and very successful features were a session for papers by graduate students and a symposium on a topic of rather general interest and practical import. The reports by the graduate students contained good material and manifested a care in preparation which in some cases might be imitated to advantage by members of the association. The symposium was on the general topic of psychoanalysis. It indicated that some scientifically trained psychologists believe that the data which the psychoanalysts call attention to call for an enlargement of the point of view of traditional psychology, although the theories and interpretations which they make are highly imaginative; while others regard Freudianism as wholly erroneous. The willingness of the association to venture upon the discussion of some of the problems which are agitating many outside the circle of professional psychologists augurs well for the influence of the profession.

The program of technical papers indicated that there is considerable interest in the questions which relate to the fundamental theory and technique of the science. The reports of actual investigations indicate that while behaviorism is generally regarded as incomplete as a theory, behavior is the chief subject of investigation. The studies of behavior, furthermore, have a considerable practical slant. They include studies of learning, mental measurement, the application of psychology in industry and education, and clinical examination. The address of the president, Dr. L. M. Terman, dealt with mental testing as a psychological method.

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