components of the doublet (in the case of the hundred or so members which *can* be resolved) are of exactly equal intensity, and therefore it seems safe to assume that the unresolved doublets are at least symmetrical, and to use them. For 3873.504, Grebe and Bachem obtained a shift of 0.58 km. (average of five consistent determinations from different plates), and Schwarzschild 0.45 km. (average of four consistent plates). No other investigators have used this line. For 3858.-822, Grebe and Bachem obtained 0.42 km. (average of six consistent determinations), St. John 0.40 (average of four different methods, of which only the first two are wholly independent and so entitled to the most weight, these two, *a* and *b*, yielding 0.46 km.), Schwarzschild 0.39 km. (average of four readings—three consistent).

Using the 0.46 km. value of St. John, these five determinations for the two lines average 0.46 km./sec. In all cases this is the shift between lines radiated by the center of the sun, and by the arc. But St. John (*loc. cit.*) and Adams have both obtained reliable evidence that at the center of the sun there is a rising current of about 0.12 km./sec., compared to the rim.[10] This tends to mask the Einstein effect. The true value of this effect, as experimentally determined, is then $0.46 + 0.12 = 0.58$ km./sec., compared to the theoretical 0.634. While the data are far too meager to draw any final conclusions, it is worthy of notice that the results of *all* observers are truly consistent on *really* good lines. The great discrepancy between St. John's and Grebe and Bachem's general averages has been the puzzling factor, thus far. The author believes that he has a partial explanation for this, and will present it in a later paper, together with a list of lines which are suitable for use, as far as condition (2) is concerned.

It might be added that, for the nine lines quoted by Grebe and Bachem[5, 6] ($\lambda$ 3858.822 and $\lambda$ 3851.427 being accidentally omitted), the agreement among different observers is worse than indicated, due to Grebe and Bachem's consistent misquoting of St. John's results, as well as other errors. The correct averages are: G. and B. 0.57, Schwarzschild 0.63, St. John 0.17 (or 0.26 using methods *a* and *b* only), Evershed and Royds 0.67. General weighted average 0.50, or 0.52, using 0.26 for St. John.

If all eleven lines are used, the averages become: G. and B. 0.52 (eleven lines), Schwarzschild 0.57 (nine lines), St. John 0.22 (eight lines, or 0.30, two good methods only), Evershed and Royds 0.67 (two lines). Average (weighted according to the number of lines), 0.46, or 0.48, using 0.30 for St. John. To all these values should be added 0.12 km. to obtain the true rim—arc value.

It should also be added that, in the author's opinion, St. John's method (*c*), and Grebe and Bachem's recent calculation[7] of 100 CN lines add comparatively little weight to the argument, as they involve the use of Rowland's standards. Since Rowland used both terrestrial and solar wave-lengths, in obtaining his table of standard lines, the Einstein shift (if real) is hopelessly involved in the measurements and can not be definitely extricated by any such method as that recently used by Grebe and Bachem.

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[10] Schwarzschild's results indicate a falling current, *not* a rising, as quoted by Grebe and Bachem, but are too discordant to have any value. St. John's are very reliable.

## A NEW HIGH TEMPERATURE RECORD FOR GROWTH

A record of growth of young joints of a prickly pear (*Opuntia*) at 50° C. and 51.5° C., and of the active elongation of etiolated stems of the same plant growing at 49° C. was published in 1917. Previously to that time Dr. J. M. McGee had found that the mature joints of the same *Opuntia* might reach temperatures of 55° C. in the open without damage, which was a record for endurance of the higher plants in air.

In the repetition of the growth measurements at the Desert Laboratory late in March, 1921, young joints which might reach tem-

peratures of 49° C. in the sun in an unventilated glass house were heated further by the use of electric grills. Temperatures were taken by mercurial thermometers with bulbs of the clinical type thrust into joints within a few centimeters of the one being measured, but which had equivalent exposure.[1]

The elongation of the joints during this youngest stage is directed by the temperature, and the retardations due to maximum night transpiration and acidity which come in later are not yet manifest. The rate of elongation therefore is greatest in midday and early afternoon. Such a joint showing a temperature by the inserted thermometer of 43.5° C. was subjected to the additional heating of the electric grill at 1:30 P.M. At 2 P.M. the temperature passed 51° C. with growth still in progress, the rate but little lessened from that of 1 mm. in 24 hours which it was showing at the beginning of the test. The temperature was now raised slowly until 3 P.M. the joint stood at 51.5° C., the maximum at which growth had ever been observed in any seed plant. At 3:10 a temperature of 54.5° C. was reached and five minutes later the readings were 55.5° C. The joint was kept for an hour between 55° and 55.5° C. during which time the auxograph tracing showed a retardation but not a stoppage of growth. The heat was shut off, the temperature soon falling to 42° C. and to 19° C. at 9 P.M., when the record assumed the character of that of the preceding day of the same joint and of a similar one standing near it.

A repetition of the tests was made next day at 10 A.M. when the joint stood at 33.5° C. The heaters were brought into action, the joint reaching 55° at 10:45 A.M. The preparation stood in the sun and was under normal conditions of ventilation and transpiration. Readings of 54.5° C. to 55.5° C. were made for a period of an hour and a half during which period the elongation was 0.2 mm. or near the maximum rate for the species and was still continuing. One heater was removed at 12:15 midday and ten minutes later the joint had fallen to 49.5° C. The cooling had resulted in a minute reverse movement of the auxograph recording lever of a character which could only be attributed to the contraction of the metal and clay of the setting. The temperature of the joints had fallen to 32° C. by 3 P.M. with no noticeable diminution of the rate, the maximum being taken to lie at some point over 40° C.

A comparison of the thermometer with U. S. Bureau of Standards No. 7618 gave an error so small as to be negligible with regard to the above data. Furthermore the young joint continued its growth at a rate normal to its developmental stage.

These and previously published measurements establish the following points:

1. Growth in *Opuntia* may begin at 9° C. and extend to 55° C.

2. Young joints of *Opuntia* may endure the maximum of 55° C. observed in mature joints in midsummer, for periods of an hour and a half, resuming elongation at lower temperatures with no perceptible after-effects.

3. A new high record for growth in *Opuntia* and for the higher plants of 55° C. (131° F.) has been established by these experiments.

4. The maximum rate of growth of *Opuntia* occurs between 37° C. and about 47°–49° C., under which conditions a biocolloid consisting of 9 parts agar and 1 part protein undergoes maximum swelling in water.[2]

5. The cell colloids of *Opuntia* include a large proportion of pentosans or mucilages, the colloidal condition of which is in general less affected by the temperatures used than albuminous substances. It is to be noted however that bacterial cells, which are highly albuminous, may withstand high tempera-

[1] MacDougal, D. T., and H. A. Spoehr, "Growth and Imbibition," *Proc. Amer. Phil. Soc.*, 56, 289–352, 1917. McGee, J. M., "The Effect of Position upon the Temperature and Dry Weight of Joints of *Opuntia*," Carnegie Inst. Wash. Year Book for 1916, p. 73. MacDougal, D. T., "Hydration and Growth," Carnegie Inst. Wash. Pub. 297, 1920. DeVries, H., "Matériaux p. l. connaisance d. l'influence d. l temperature s. l. plantes," *Arch. Néerlandaises*, III., p. 3, 1870.

[2] MacDougal, D. T., "The Relation of Growth and Swelling of Plants and Biocolloids to Temperature," *Proc. Soc. Exper. Biol.*, 15, 48–50, 1917.

tures, such as those of boiling water. The presence of salts or other compounds may be accountable for the resistance of the proteins to high temperatures.

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## THE AMERICAN MATHEMATICAL SOCIETY

The two hundred and fourteenth regular meeting of the American Mathematical Society was held at Columbia University, on Saturday, February 26, 1921, extending through the usual morning and afternoon sessions. The attendance included thirty-five members Ex-president H. B. Fine occupied the chair. One hundred and fifteen new members were elected, and twenty-four applications for membership in the society were received.

The council voted to accept the invitation to affiliate with it extended to the society by the American Association for the Advancement of Science.

Professor E. B. Van Vleck was appointed representative of the society in the division of physical sciences of the National Research Council, to succeed Professor H. S. White. The final report of the committee on membership and sales was presented by its chairman, Professor E. R. Hedrick; in all one hundred and thirty-two applications for membership have been received through this very efficient committee. Questions having arisen concerning dues of foreign members, concerning sales and exchanges of publications with foreign societies and libraries, and concerning individual or concerted efforts to aid foreign journals, a committee was appointed by the council to consider these and related problems.

A letter was read to the council from ex-secretary F. N. Cole donating to the society the sum which accompanied the testimonial tendered him at the preceding meeting of the society in recognition of his very distinguished services. It was voted that the council accept the gift and extend to Professor Cole its heartiest appreciation of his generosity; it was further voted that this fund shall constitute, and be designated as, the Cole Fund. A committee was appointed to consider the use to which the income can best be devoted. The council approved the suggestion that the present volume of the society's *Bulletin* be inscribed to Professor Cole.

A letter of felicitation was sent to Professor Mittag-Leffler, of Stockholm, on the occasion of the seventy-fifth anniversary of his birth.

The following papers were read at this meeting:

*Coefficient of the general term in the expansion of a product of polynomials:* L. H. Rice.

*The mathematical theory of proportional representation, with a substitute for least squares:* E. V. Huntington.

*On the apportionment of representatives:* F. W. Owens.

*On the polar equation of algebraic curves:* Arnold Emch.

*Generalization of the concept of invariancy derived from a type of correspondence between functional domains. Second proof of the finiteness of formal binary concomitants modulo p:* O. E. Glenn.

*Concerning the sum of a countable number of point sets:* R. L. Moore.

*On the simplification of the structure of finite continuous groups with more than one two-parameter invariant subgroup:* S. D. Zeldin.

*Periodic functions with a multiplication theorem:* J. F. Ritt.

*Note on equal continuity:* J. F. Ritt.

*Expressions for the Bernoulli function of order p:* I. J. Schwatt.

*The expansion of a continued product:* I. J. Schwatt.

*Method for the summation of a family of series:* I. J. Schwatt.

*Note on the evaluation of a definite integral:* I. J. Schwatt.

*A property of the Pellian equation with some results derived from it:* John McDonnell.

*A necessary and sufficient condition that the sum of two bounded, closed and connected point sets should disconnect a plane:* Anna M. Mullikin.

*Some empirical formulas in ballistics:* T. H. Gronwall.

*Summation of a double series:* T. H. Gronwall.

*A geometrical characterization of the paths of particles in the gravitational field of a mass at rest:* L. P. Eisenhart.

*The equations of interior ballistics:* A. A. Bennett.

The next meetings of the society will be at Chicago on March 25 and 26, and at New York, in April.

R. G. D. Richardson,
*Secretary*